Assessing the potential impact of industry 4.0 in South Africa's small and medium enterprises

A minor dissertation submitted in partial fulfilment of the degree of

MASTER OF PHILOSOPHY

in

ENGINEERING MANAGEMENT

in the

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

of the

UNIVERSITY OF JOHANNESBURG

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15 June 2020

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Declaration

I, Ntuthuko Gift Mbuyane, hereby declare that this minor dissertation is the result of my own original work, and that the research and investigation were done solely for the purpose of this study.

I further declare that the work from other books and publications has been properly referenced.

Abstract

Small business fulfils a major economic gap in the world and in South Africa, contributing 56% to private employment. The significance of small businesses is vital as they provide over 60% of employment. Small, medium enterprises (SMEs) are common in developing countries as a result of the crucial role they play within the South African economy.

Small businesses, regardless of their relevance, still face multiple challenges that hinder their growth and endanger their existence. These challenges include the lack of finance, low market accessibility and more. There are however, opportunities that industry 4.0 provides to the manufacturing sector to improve their processes. These opportunities can mitigate some of the challenges, whilst improving their manufacturing and customer service processes. One of the possibilities that this technology can afford small manufacturing businesses, is greater efficiency, which may result in increased financial savings. Another opportunity that comes with industry 4.0 is a smart economy, which can allow these businesses to participate in more markets.

Having identified the opportunities that come with industry 4.0, small businesses still face challenges in adopting and implementing this technology. This barrier and challenges are similar, which includes the high cost of implementation, making it impractical, together with the scarcity of skilled workers in industry 4.0. Moreover, SMEs still have a negative perception with regards to the adoption of industry 4.0 as many believe that it may leave people jobless.

By overcoming these barriers and utilising the industry 4.0 opportunities, this will empower small businesses to thrive and as a by-product, change the negative perceptions.

Acknowledgements

The life I now live in the body, I live by faith in the Son of God, who loved me and gave himself for me. I would like to thank my Lord and saviour, Jesus Christ who allowed me to take this journey and availed all that was needed in this long walk. I do all in His name and for His Name.

I would like to thank and acknowledge these amazing individuals and organisations who helped me with this paper

1. My lovely wife, Slindile Mbuyane. Your unending love and support is what drives me to do the best. I appreciate the role that you play in my life.
2. My research supervisor, Prof JHC Pretorius, thank you for the insight and guidance that made this document a success.
3. My research co-supervisor, Prof A Marnewick, thank you for your patience and feedback that was much needed for this research to be a success.
4. My family and friends, who motivated me when there was no drive left in me.
5. To my son, Yasipha Mbuyane, this is a sign that you can achieve this and greater,
6. To my sponsor, the National Research Foundation, I would have never enrolled had this organisation not provided the much needed funds, thank you and may you continue to support us.
7. Thank you to the University of Johannesburg and Statkon for the contribution they had in the success of this document.
8. Finally, to my late friend, Phiko Jolobe, Ntwana yam, I know you would have been proud.

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Abbreviations and acronyms

AI	Artificial Intelligence
BEE	Black Economic Empowerment
BRICS	Brazil, Russia, India, China and South Africa
CAD	Computer Aided Drawing
CEO	Chief Executive Officer
COO	Chief Operation Officer
CPS	Cyber Physical Systems
DFKI	Deutsches Forschungszentrum für Künstliche Intelligenz
GDP	Gross Domestic Product
ICT	Information Communication Technology
IoT	Internet of Things
IT	Information Technology
I4	Industry 4.0
KMO	Kaiser Meyer Olkin
KZN	KwaZulu-Natal
MIS	Mean Item Score
MSA	Mean System Analysis
M2M	Machine to Machine
NEF	National Empowerment Fund
NIST	National Institute of Standards and Technology
RFID	Radio Frequency Identification
R&D	Research and Development
SAPS	South African Police Service
SEDA	Small Enterprise Development Agency
SME	Small Medium Enterprises
SPSS	Statistical Package for Social Sciences
USA	United States of America

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CHAPTER 1: INTRODUCTION

Over the years there has been compelling technological advancement that is transforming most industries towards digitalisation (Alcácer & Cruz-Machado, 2019). industry 4.0 (I4) was first discussed in 2011 (Roblek, Meško and Krapež, 2016). It caught the attention of many stakeholders from governments, businesses, academics and politicians around the world (Sung, 2018; Santos C, Mehrsai. A, Barros. A, Araujo. M, Ares. E., 2017; Pereira & Romero, 2017). The manner of production, where there are a number of manual operators, is changing as technology moves toward a high level of automation (Sung, 2018). The use of artificial intelligence, the Internet of Things (IoT), data analytics, cloud computing, and robotics are some of the terms that describe industry 4.0 (Luthra & Mangla, 2018). The use of a cyber-physical system (CPS) allows machines, humans and products to communicate over the Internet (Nilsen & Nyberg, 2016). The use of this technology is making products smarter as it allows the microchip in the product to communicate with the machine for the specifications of the product (Sung, 2018). The increase in production is the main reason why this revolution is practical whilst also maximising personalised products (Roblek, Meško & Krapež, 2016). The fundamental concepts of Industry 4.0 include smart manufacturing, smart products, and self-organisation (Roblek et al., 2016).

Industry 4.0 is not only causing a change in the processes of manufacturing but will have an impact on the manner of how business is done (Moester, 2017). The digital transformation is accelerated by the introduction of technologies that focus on interconnectivity, flexibility and better quality (Moester, 2017). Organisations are investing funds in research on how the dawn of Industry 4.0 will affect their businesses (Moester, 2017).

1.1. Background

Small Medium Enterprises (SME) are a major contributor to many countries in the world and this has resulted in a more focused approach on the success of SMEs (Olawale & Garwe, 2010). SMEs are said to be contributing 56% employment to the private sector, whilst producing 36% of the gross domestic product (Olawale & Garwe, 2010). South Africa’s unemployment rate is over 25% according to Statistics South Africa (Statistics South Africa (StatsSA), 2014). With the high level of unemployment, one of the best methods to alleviate this, is to start, support and grow small businesses (Olawale & Garwe, 2010). SMEs contribute over 60% to job creation (Olawale & Garwe, 2010). Furthermore, according to the Edinburgh Group (Group, 2013), SMEs are more common in developing countries, therefore, this indicates that SMEs are a vital element in South Africa's economy.

Table 1.1 SME Contribution to employment by region - Cumulative *median*

Median across region	**SME 100**	**SME 150**	**SME 200**	**SME 250**	**SME 300**	**SME 500**
Africa	54.77	63.79	68.15	78.85	80.56	85.11
East Asia and Pacific	56.79	61.58	67.42	65.70	71.34	71.34
Europe and Central Asia	44.71	53.08	59.46	66.32	67.48	75.47
Latin America	53.72	56.71	64.36	67.77	70.99	78.26
Middle East and North Africa	31.20	48.1	36.63	57.31	58.56	62.3
North America	41.73	39.34	41.99	NA	59.27	56.58
South Asian	56.68	65.29	73.63	78	80.26	88.56

Businesses that employ technology in their processes become more efficient and are able to enjoy growth (Nikoloski, 2014). South Africa is one of the examples of emerging economies and greatly relies on the manufacturing sector for growth (StatsSA, 2014). Many factories have started to embrace the technology that comes with industry 4.0 (Du Plessis, 2017).

1.2. Background to the problem

Currently, the literature available on industry 4.0, particularly for South African SMEs, is limited. There is an inadequate detail or framework that explains how this emerging technology can be implemented. Germany and Korea are two of the countries that are leading in the adoption of this technology, however, their adoption is based on the context of the country (Sommer, 2015; Sung, 2018). The adoption of industry 4.0 will improve collaboration between companies, increase productivity, better simulation and collaboration tools (Moraes & Lepikson, 2017).

Shwab (2016) asked that with all the hype around the 4th Industrial Revolution, the critical question that remains unanswered is that: Are we preparing for this wave? Moreover, with the research done in Korea, Kim (2018) highlighted that it was not prepared for the 4th Industrial Revolution (Sung, 2018). This may not only apply to Korea but to many other countries, including South Africa. If many countries have no understanding of the effects, this may end by not only causing economic issues but may spill over to social issues that can be a byproduct of the technology for which the countries are not yet prepared.

1.3. Problem statement

South Africa is one of the leading emerging economies, as it keeps up with the latest innovations. Moreover, because South Africa has embraced globalisation, it requires staying abreast of the technology to have better relations with other countries in this regard. Industry 4.0 provides opportunities to improve efficiency and productivity. The concept of smart technology has been vaguely defined and this, therefore, means that the manner of adoption will differ. There are multiple factors that vary in definitions, such as facilities, resource management, logistics, education, amongst others (Du Plessis, 2012). Since SMEs have been recognised as key contributors to alleviating unemployment and assisting in growing the economy of South Africa, it is vital that there be a clear framework of how small businesses can use technology to improve their products and services.

To enhance and improve the contribution that SMEs are making to the economy, this study sought to identify the challenges faced by SMEs and to identify what opportunities industry 4.0 will provide to overcome these challenges.

1.4. Research Questions

The purpose of this study was explored by answering the following questions:

- What are the challenges that SMEs are facing?

- What opportunities does Industry 4.0 provide for the manufacturing processes of SMEs?

1.5. Research objective

The objective of this study was to identify what opportunities industry 4.0 would afford SMEs, and to identify the challenges that are faced by South African SMEs. There are a number of factors that make it difficult for SMEs to grow and to find a solution, which can result in greater stability and potential growth of these businesses. The stakeholders that were considered were:

- Micro businesses
- Small businesses
- Medium businesses

1.6. Research Design

The research focus was to do an in-depth study of the challenges of manufacturing SMEs in South Africa. This was done through the collection of data from multiple small businesses. The researcher used a quantitative method that employed online questionnaires to collect the data. The data was compared to case studies that were extracted from earlier literature. Furthermore, the research adopted an explanatory method to achieve the findings as it sought to understand and address the challenges faced by manufacturing SMEs.

1.7. Research Rationale

The purpose of this study was to assist small companies by highlighting the challenges faced with the use of traditional methods of production. These challenges were addressed by the opportunities that could be obtained by adopting 4IR in the manufacturing processes. The body of knowledge must assist with a proper framework if the technology is to be well embraced and integrated with the country's socioeconomic status. The literature review focused on countries with leading economies, and not emerging countries, which could adopt industry 4.0. This would have to be properly aligned as the economic muscles of these countries are not similar, the adoption will have to be customised to their needs.

1.8. Study Overview

The layout of the document is as follows:

Chapter 1: Introduction and orientation

This chapter introduces the research study and provides an overview of the objectives and its significance. The content of the research was highlighted to communicate the purpose of the research and outlined the research questions.

Chapter 2: Literature review

This chapter provides a review of the available literature on the challenges that are faced by SMEs in South Africa. This chapter also highlights the opportunities that industry 4.0 will potentially have on the manufacturing sector.

Chapter 3: Research methodology

This chapter presents a detailed account of the methodology and the research instruments employed to collect the data.

Chapter 4: Data analysis and presentation

This chapter presents the data analysis. The results are discussed in detail to provide a comprehensive overview of the outcomes of the analysis.

Chapter 5: Conclusion and recommendations

This chapter provides the conclusion and recommendations that are based on the results of the research and makes recommendations for future research.

1.9. Chapter Conclusion

Small businesses are the heart of the South African economy and therefore, much consideration must be given to them to stay relevant. There are many manufacturing plants in South Africa that employ a great number of individuals., The processes that these organisations use have not yet included automation and digitisation. However, these small businesses have not been able to maximise their production nor increase their profits due to the lack of technology.

Industry advanced countries have already started to adopt Industry 4.0. These countries include the likes of Germany, the United States of America, Korea, China, and Sweden, amongst others, which are some of the countries that have invested heavily in the adoption of Industry 4.0. South Africa as a member of the Brazil, Russia, India, China and South Africa (BRICS) countries, participates in global markets and global economies.

Small businesses can exploit the use of technology to enhance their processes. This research sought to highlight challenges that were faced by manufacturing SMEs. Moreover, the research addressed these challenges as opportunities that Industry 4.0 could provide.

This section highlighted the problem area, and the value that this study would have on this. The next chapter provides a review of the available literature concerning the challenges that manufacturing SMEs in South Africa face and the opportunities that Industry 4.0 will bring.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In the field of manufacturing and production, there is constant development globally of the technology being used (Liao et al., 2017). Industry 4.0 is a term used for the current automation and computerisation of the manufacturing processes (Du Plessis, 2017). Whilst there has been no agreement on what truly defines Industry 4.0, Arvind and Bourne (2016) defined it as cyber systems that will allow manufacturing plants to have greater flexibility with regards to the manufacturing processes. Bourne (2016) added that this would enable the customisation of products and have a greater output. Sommer (2015) further agreed with the above author by breaking it down further to argue that in the age of Industry 4.0, it is the products that now inform the machines autonomously on what needs to be done. Sommer (2015) in short defines Industry 4.0 as objects becoming intelligent and making decisions. Moraes and Lepikson (2017) added a definition of Industry 4.0, which is simply put as computer technologies systems to communicate and control industrial systems in real-time.

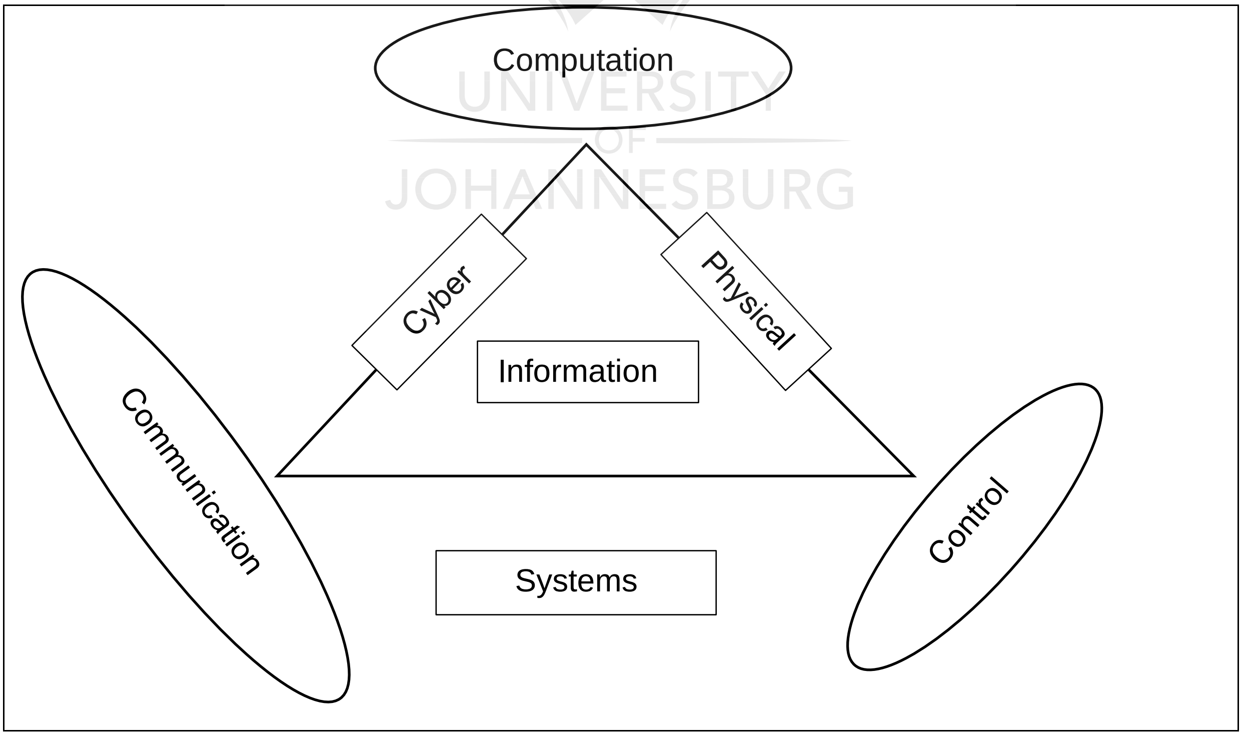

Figure 2. 1 Definition of Industry 4.0 (Guilhem, 2018)

Germany used the definition for industry 4.0 as the objects that become intelligent by having sensors and radio frequency identification (RFID) tags that will be used (Sommer, 2015). Other authors and countries have shared the same sentiments in defining industry 4.0. The most common definition of Industry 4.0 has been to do with the concept illustrated in Figure 2.1, which is cyber-physical systems (CPS) (Harrison, Vera & Ahmad, 2016; Kusiak, 2019). The use of CPS enables improved communication using computers that have the ability to control machinery (Pereira & Romero, 2017). CPS is the evolution of embedded systems as it requires devices to have abilities such as communication capabilities and interaction with other systems, besides processing but will enable correspondence with the virtual world (Moraes & Lepikson, 2017). Most of the devices that will be used in the Industry 4.0 factory must have smart capabilities. The manufacturing industry's increase of automation has led to the development of intelligent systems and autonomous decision-making processes that are vital to achieve optimisation of processes and add value in the supply chain in almost real-time (Moraes & Lepikson, 2017).

Figure 2.2 shows the four major phases of the industrial revolution, namely: manual labour, mechanisation, electrification and lastly, digitisation (Lorimer, 1983; Qin, Liu & Grosvenor, 2016; Pereira & Romero, 2017) .

The First Industrial Revolution began in Britain where an agrarian economy evolved to an industry-based economy. This transformation came as a result of the increasing technological advances that catered to the increasing population (Nuvolari, 2018). The revolution employed the use of mechanical tools that were powered by steam-generated engines. The First Industrial Revolution had a positive effect on production as there was an increase in demand (Pradhan & Agwa-Ejon, 2018). The growth of the industries led to the Second Industrial Revolution that was fast-tracked by urbanisation and began in the U.S.A (Jull, 1999).

The Second Industrial Revolution began mass production using assembly lines that were the creation of Henry Ford (Pradhan & Agwa-Ejon, 2018). This revolution was able to fuel productivity whilst lowering the prices and as a result, there was greater economic growth (Liao et al., 2017). This had an unforeseen consequence as the rise of machines displaced labour and increased unemployment (Jull, 1999).

The Third Industrial Revolution was built on the foundation of the second. The mass production and automation of processes sustained growth and facilitated globalization, whilst maintaining lowered labour costs (Nuvolari, 2018). This was a revolution that was influenced by the advancement of information and communication technologies. This is known as the digital revolution (Tien, 2012). The Third Industrial Revolution was more concerned about sustainable development and moving away from fossil fuels as a means to limit climate change (Alexandre, 2014). The use of modern technology eliminated labour, thereby minimising the effort and time that workers invested (Tien, 2012).

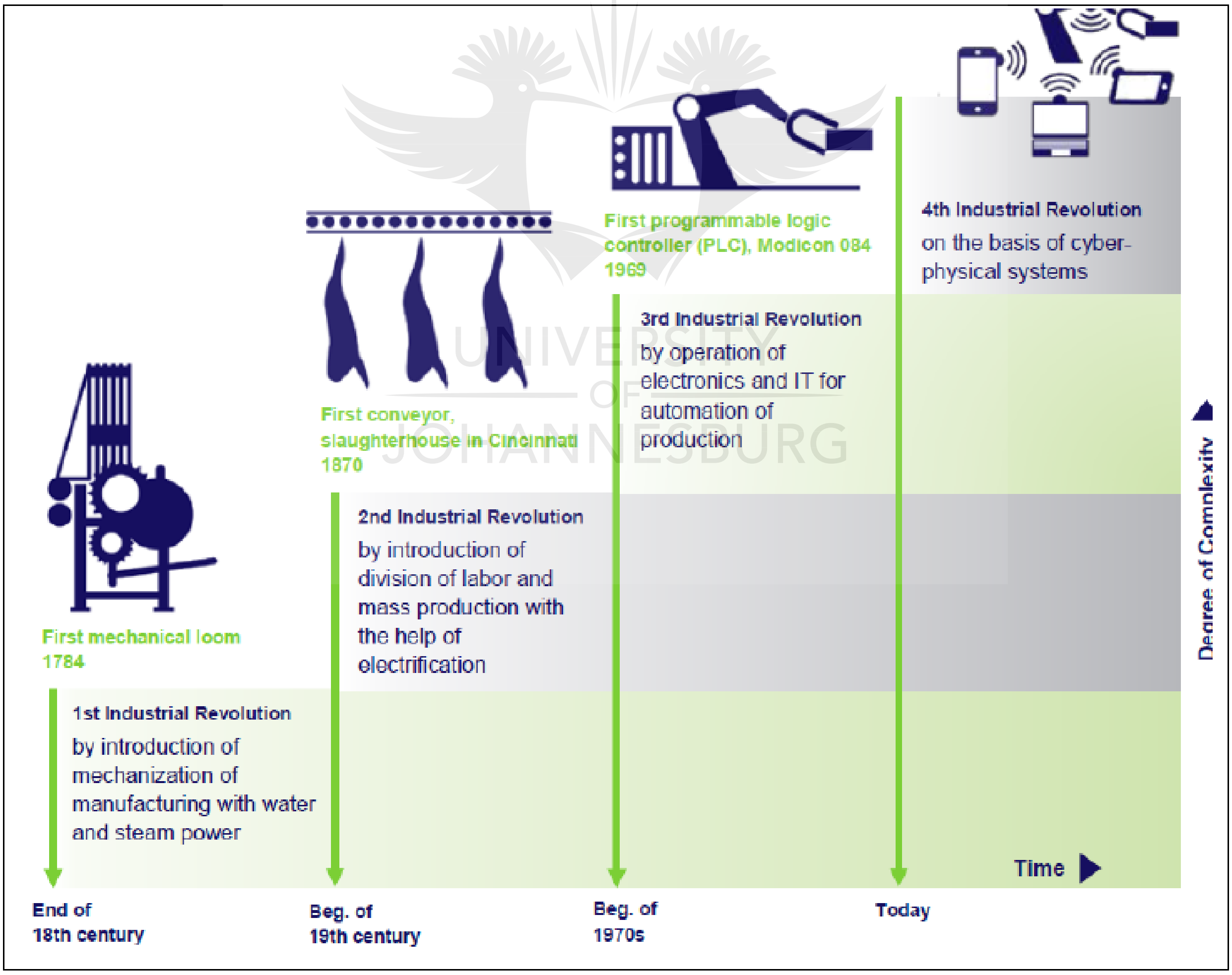

Figure 2. 2 Phases of the Industrial Revolutions (DFKI, 2011)

The digital revolution gave birth to a revolution that connects more people, machines and processes to an interconnected global system (Oesterreich & Teuteberg, 2016). The Fourth Industrial Revolution enables a virtual world the ability to monitor and control the physical world in real-time (Du Plessis, 2017).

The Fourth Industrial Revolution was founded on the cyber physical systems that are highly dependent on smart production, big data, artificial intelligence, 3D manufacturing and more (Lu, 2017). Figure 2.3 depicts the elements and technologies that are associated with Industry 4.0 in accordance with other studies (Nowak et al., 2012; Pradhan & Agwa-Ejon, 2018).

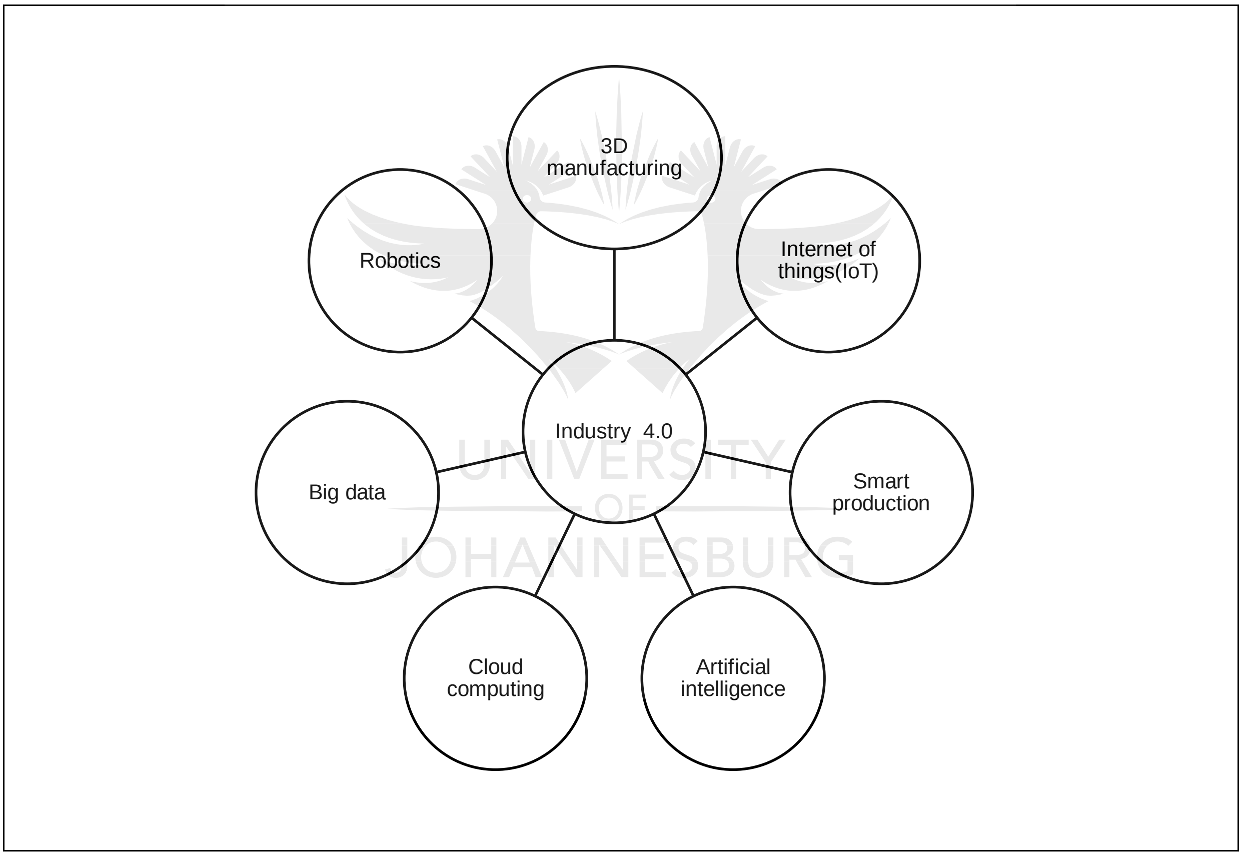

Figure 2.3 Elements of Industry 4.0 (Pradhan and Agwa-Ejon, 2018)

3D Manufacturing

In the engineering phase, 3D materials, products and production processes are already in use however, future simulations will be part of the integrated process. The tools will be integrated with a machine code which will minimise the gap between design, prototyping and production (Moraes & Lepikson, 2017). The simulations are able to generate real-time data that reflect the physical system into the virtual system. This permits operators to test and optimise the machine settings for the next product-in-line in the virtual world before the physical one and, thereby reducing the setup time and increasing quality (Moraes & Lepikson, 2017).

Internet of Things (IoT)

The Internet of Things (IoT) is a new concept that is rapidly growing. The goal of IoT is to create small physical sensors in objects that are used every day in a manner that they are not visible but can still communicate at a computerised level (Alexandre, 2014). Although there has been an agreement on what defines IoT, such as the use of technology to have omnipresence and develop a synergy between the most diverse objects and the ability of systems to share information amongst themselves and with human beings (Alexandre, 2014). IoT can also be defined as the conceptual network between computers and physical objects that allow for virtual entities to extract information and control physical entities (Alexandre, 2014).

Smart production

Smart production uses production lines that are equipped with sensors, actors and autonomous systems (Roblek et al., 2016). The machines and equipment have the capability to improve efficiency through self-optimisation and autonomous decision-making (Roblek et al., 2016). One of the terms used to describe the production of tomorrow, is smart manufacturing (Kusiak, 2019). The concept of smart production shares the same foundations of improved flexibility by integrating the cyber physical systems in a production line (Kusiak, 2019). There is yet to be an agreed-on definition of the term smart production. According to the National Institute of Standards and Technology (NIST), smart manufacturing is a fully integrated, collaborative manufacturing system that responds in real-time to meet changing demands and conditions in the factory, in the supply network and customer needs (Kusiak, 2019). As discussed by Kusiak (2019), smart manufacturing integrates manufacturing assets of today and tomorrow with sensors, computing platforms, communication technology, control and predictive engineering to achieve the set goals (Kusiak, 2019).

Artificial intelligence

Artificial intelligence(AI) is the ability of a robot to fulfil its role in manufacturing as an independent productive unit (Santos et al., 2017). One of the greatest advantages that AI has over a rule-based system is that it can handle new situations that are not covered in the knowledge base (Ali Chaudhry, Ali Khan & Shami, 2004). AI can be best described as the system that exhibits characteristics that are associated with intelligence in human behavior (Ali Chaudhry et al., 2004). There are several tools that are being used by AI to solve problems in the manufacturing field, which include expert systems, fuzzy logic, neural networks, generic algorithms and constraint satisfaction (Ali Chaudhry et al., 2004).

Cloud computing

Cloud computing has been implemented in some enterprises as a management tool (Moraes & Lepikson, 2017). Cloud computing technology permits information to be shared in real-time. This technology allows for the monitoring and control processes to be cloud-based (Alexandre, 2014). The future of cloud that is at hand will be able to interact with the system cloud to have the capacity to ensure independent operability, which will be achieved through autonomous subsystems (Alexandre, 2014).

Big data

The ever growing use of networks and sensors in machinery increases the generation of high volume data, also known as big data (Du Plessis, 2017). According to Manyika, who is referenced by Du Plessis, big data is further explained as the datasets that have sizes beyond the ability of a typical database software tools to capture, store and manage data (Du Plessis, 2017). McAfee in Du Plessis paper further highlighted that big data is not only analytics applied to these big data sets, which could not be done before due to technological limitations, but it is a movement that seeks to extract intelligence from this data and translate that into business advantages (Du Plessis, 2017).

Robotics

Manufacturing has been using robots to handle complex and critical processes, however, robots are becoming more autonomous and flexible (Moraes & Lepikson, 2017). Robots will eventually be able to communicate amongst themselves and work safely with humans (Moraes & Lepikson, 2017). The autonomous production methods that are powered by robotics are able to complete tasks intelligently and without a need to isolate the working area (Bahrin.M, Othman.M, Azli. N, Talib. M., 2016). The integration of robotics into human working spaces becomes more economical and productive and gives greater applications to the industries. Smart robotics will not replace humans but will allow for human-machine collaboration through smart sensors (Bahrin et al., 2016). The use of these devices will promote innovation since the prototypes will be produced quickly without having to retool or set up new production lines (Bahrin et al., 2016).

The Fourth Industrial Revolution builds on the Third Industrial Revolution, however, it brings new elements as it synergises multiple technology disciplines and increases the velocity of production. Lastly, Industry 4.0 is transforming the traditional methods of production and making them smart (Roblek et al., 2016). The robots that are used are more capable and flexible to conduct complex processes and systems. Smart factories are believed to form part of smart cities that are powered by renewable energy sources (Du Plessis, 2012). Du Plessis J (2017) agreed with the above authors that the main components of Industry 4.0 are the Internet of Things, cyber physical systems, and smart factory.

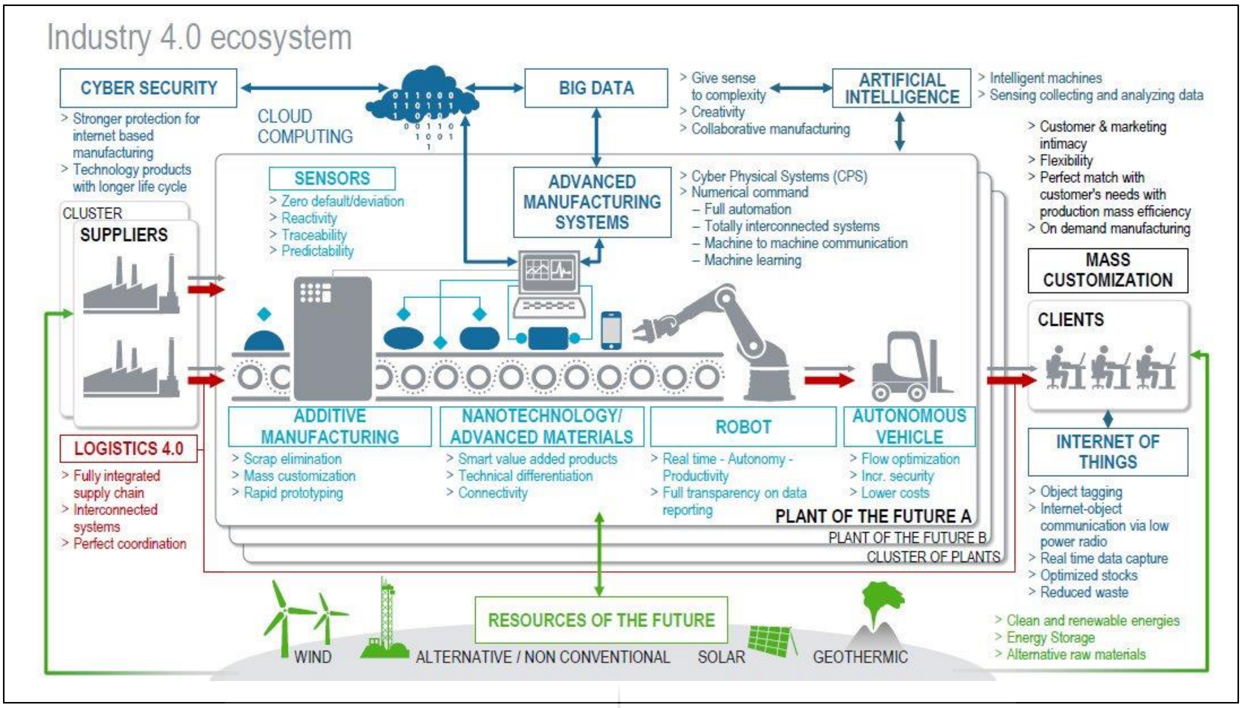

Figure 2.4 Industry 4.0 Ecosystem (Du Plessis, 2017)

Figure 2.4 is a reflection of what a smart factory might possibly be like. The Figure 2.4 highlights that there are no manual labourers in the process but most of the activities that are performed are automated (Du Plessis, 2017). The above Figure 2.4 shows how every product has an RFID chip that contains information of how it is to be processed (Sommer, 2015). This information may include the quantity, type of product and the label for that product. The RFID chips that are in the product, will assist in traceability of the product and how the product is performing in the market (Nilsen & Nyberg, 2016) The product communicates with the machine at every process, informing the machine how the product is to be manufactured (Sommer, 2015). The computer will then verify the quality of the product against the description on the label and the order (Nilsen & Nyberg, 2016). The conveyor belts will be controlled by the machinery communicating what is to happen next. The information that will be collected through the use of big data and cloud computing as shown in Figure 2.4 will be used to improve the product to meet the required customer needs (Moester, 2017). The Figure 2.4 finally indicates the ability that customers will have in product customisation that can be achieved in a quicker and smarter way (Du Plessis, 2017).

The use of technology has a tremendous impact on business operations. Regardless of the size of the organisation, technology and its use, both intangible and tangible benefits will assist to grow profits and meet customer needs (Nikoloski, 2014). Technology affects the culture, productivity, security and the sustainability of the business (Nikoloski, 2014). Small businesses require technology to improve their efficiency and stay connected to their customers. With the use of technology in small manufacturing plants, the business can eliminate shortcomings, such as delays in processes and communication (Nikoloski, 2014). SMEs are now applying reengineering business processes that employ technology for drastic improvement in the much needed areas such as cost, quality, service and agility (Nikoloski, 2014). Technology plays a significant role in the growth of small businesses (Müller, Buliga & Voigt, 2018). As organisations seek to add value to the experience given to customers, SMEs are adopting technology and innovation to their processes to achieve this (Müller et al., 2018).

2.2 Significance of small-medium enterprises

There is a growing focus on the role that SMEs play in the economic development of South Africa. SMEs have been characterised as major contributors to job creation, they assist big business and lastly national economic hubs. In developed economies, SMEs remain a significant contributor to the employment of workers (Abor, 2010). Governments have taken great interest in SMEs and this has resulted in policies being drafted that will empower the growth of SMEs (Olawale & Garwe, 2010), such as the broad lack of economic empowerment, access to funding with the likes of organisations, such as the National Economic Forum(NEF). SMEs produce over 90 % of private businesses and create over 50% employment in most African countries (Abor, 2010). In South Africa it is estimated that over 60% of business entities are SMEs (Du Plessis, 2012). Moreover, these SMEs contribute between 52 to 57% to the GDP and employ over 61% (Du Plessis, 2012). SMEs play a crucial role in the growth and success of the South African economy (Abor, 2010). The National Small Business Act 106 of 1996 is the framework that is used in South Africa that describes the categories of businesses The Act uses the following elements to determine the category in which a business is to be placed; number of employees, annual turnover, and gross assets, which exclude fixed property. The definitions of the different enterprises are as below (The President’s office, 2004)

- Survivalist enterprise: the income of the enterprise is less than the minimum income standard. This category includes hawkers, vendors and subsistence farmers.
- Microenterprise: The income that is generated by this establishment is less than the VAT registration limit (less than R150 000 per year). These enterprises are not formalised in terms of registration. These include spaza shops, minibus taxis and household industries. These businesses employ less than 5 people.
- Very small enterprise: These establishments have no more than 10 paid employees. These businesses have a formal market and access to use technology.
- Small enterprises: These businesses have a maximum of 50 people and practice more complex business.

Medium enterprises: These enterprises have a maximum of 200 workers and are mostly involved in the mining, manufacturing and construction sectors.

Table 2.1 The National Small Business Acts categories according to South african small business (Abor, 2010)

Enterprise size	**Number of employees**	**Annual turnover (Rand)**	**Gross Assets (Excluding property)**
Micro	Less than 5	Less than R150 000	Less than R100 000
Very small	Less than 10	Less than R500 000, depending on industry	Less than R500 000
Small	Less than 50	Between R2 million to R25 million, depending on industry	Between R2 million and R4.5 million
Medium	Less than 200	Between R4 million and R50 million, depending on industry	Between R2 million to R18 million, depending on industry

The importance of SMEs in countries such as South Africa, cannot be ignored. Leboea (2017) argued that for the country to have maximum gain from SMEs, the enterprises must be supported and improved to operate to their full capacity. That can only be achieved by having sufficient resources.

The high rate of unemployment is one of the most prominent issues faced by developing countries (Statistics South Africa (StatsSA), 2014). SMEs use production systems that are more labour intensive when compared to their larger counterparts (Statistics South Africa (StatsSA), 2014). This then highlights that SMEs have a high labour absorption and are able to reduce the percentage of unemployment in South Africa (Leboea, 2017). The increment of the number of people that are employed has a direct impact on poverty reduction. Even though there are many challenges faced by SMEs, regardless of what this research reveals, they continue to grow (Abor, 2010). SMEs also contribute to improving equality in previously disadvantaged communities (Leboea, 2017). The disadvantaged communities are those that were discriminated against by the apartheid regime and denied by law, the opportunities to participate economically (Leboea, 2017). SMEs are the main forms of employment in those communities. With the increase in income of those households, the gap of inequality is reduced (Leboea, 2017).

All businesses, especially SMEs, require financial resources for the business to continue trading. Lack of finance can limit business growth (Du Plessis, 2012). This has been one of the reasons why SMEs have not been able to make an investment in information technology (White, 2005). Technology is a key driver of many manufacturing firms as it assists to maximise business opportunities (Pradhan & Agwa-Ejon, 2018). Many manufacturing SMEs that have been newly formed, may not have access to the funding to buy the necessary technology (Timm, 2015). Smallbone et al stated that the cost of production can affect the growth of SMEs. The rising cost of essential inputs like electricity and fuel is also another limitation for the success of SMEs.

The economic factors of the market and country have a direct impact on the charisma and feasibility of certain strategies and suggestions like the adoption of smart systems. The economic valuables include policies of the government, fiscal policy, interest rates and the foreign exchange rate. These economic variables determine the demand for goods and services (Abor, 2010). Big businesses and SMEs are still trying to recover from the technical recession that took place in 2008 (Bureau for Economic Research, 2016). This has affected sales negatively and increased the level of unemployment as many SMEs have had to cut down on labour to keep themselves afloat (Olawale & Garwe, 2010). The economic state of the country directly impacts SMEs, which has made businesses weary of investing in technology. Even though the costs are high there is potential to improve profit margins.

2.3 Challenges faced by South African SMEs

The South African Police services statistics in 2009 revealed that business-related crimes had increased (Timm, 2015). This has propelled companies to invest in more security measures compared to the investment that is made on their machinery and technology (Abor, 2010). Moreover, corruption in both the private and public sectors has gained momentum (Du Plessis, 2012). Corruption in SMEs is mostly focused on compliance and bureaucracy (Du Plessis, 2012). Table 2.1 depicts the challenges that face SMEs in South Africa. These include crime, labour unrest, lack of both finances and ICT infrastructure, which hinder a lot of small businesses from growing.

Table 2.2 Summary of the challenges in South African manufacturing SMEs

Challenges	**A roadmap for smart city services** (Du Plessis, 2012)	**Issues in SME development in Ghana and South Africa** (Abor, 2010)	**Opportunities and challenges of embracing smart factory in South Africa** (Pradhan & Agwa-Ejon, 2018)	**Obstacles to the growth of new SMEs in South Africa: A principle component analysis approach** (Olawale & Garwe, 2010)	**The causes of the failure of new, Small and Medium Enterprises in South Africa** (Timm, 2015)	**The factors influencing SME failure in South Africa** (Leboea, 2017)	**Factors affecting the performance of small, medium enterprises (SMEs) in the manufacturing sector of Cairo, Egypt** (Fouad, 2013)
Crime and corruption	✓			✓	✓	✓	
Labour unrest				✓		✓	
Cost of technology	✓		✓		✓		
Lack of ICT	✓	✓	✓	✓	✓	✓	✓
Market accessibility		✓		✓	✓	✓	
Lack of finances	✓	✓	✓	✓	✓	✓	✓
Inadequate skill levels and training	✓	✓	✓			✓	✓
Lack of government support	✓		✓	✓	✓		✓

2.3.1 Crime and corruption

A study that was done by the United Nations office revealed that South Africa is amongst the top five (5) countries with a high rate of murders (Olawale & Garwe, 2010). The authors further stated that although multiple categories of crime have fallen, business crimes have shown a rise according to the South African Police Service (SAPS) (SAPS, 2018)(Olawale & Garwe, 2010). Crime and corruption are amongst the leading causes of business failures in South Africa (Leboea, 2017; Du Plessis, 2012). As a result of the high levels of crime, business owners and entrepreneurs do not seek a competitive edge over their competition nor grow their market shares but rather invest in operational matters related to the high crime levels (Leboea, 2017; Olawale & Garwe, 2010). Furthermore, SMEs (Shanmugam & Ali, n.d.) are more exposed and susceptible to fraud by employees and because SMEs are financially lean, it can be difficult for the organisation to absorb the loss. Despite the efforts that government has invested in fighting crime, entrepreneurs are still adamant that crime is their biggest threat to their sustainability and growth (Leboea, 2017).

The literature revealed that employees of SMEs are likely to commit fraud when they have an opportunity (Shanmugam & Ali, n.d). Employees commit fraud of two categories; the first is the employees being devious at the workplace by slowdowns, and sick leave abuse (Shanmugam & Ali, n.d.). The second type of fraud is stealing company materials or funds or both. These categories are said to be as a result of financial pressure that the employees are facing (Shanmugam & Ali, n.d.). The crime committed in-house and externally both have a massive impact on the profitability and sustainability of the SME that is impacted (Shanmugam & Ali, n.d; Olawale & Garwe, 2010). It is not only employees that are involved in crime and corruption but the SMEs themselves are involved. Corruption has limited the growth of SMEs that do not involve themselves in illegal acts (Olawale & Garwe, 2010). Moreover, a number of SMEs lack the capacity to comprehend and align with compliance and legislation (Kunene, 2008). The high cost of compliance is not only a threat to the SME sector but has resulted in SMEs involving themselves in corruption in a quest to comply (Du Plessis, 2012) (Olawale & Garwe, 2010; Kunene, 2008). In South Africa, the literature reveals that businesses with an average of R105 000 earnings annually remain compliant with the regulations (Du Plessis, 2012). On the contrary, when considering the challenge of corruption, the finding was that government support and corruption does not have an impact on the day-to-day operations of the business (Du Plessis, 2012).

2.3.2 Lack of ICT capabilities

SMEs in developing countries are typically faced with more challenges in acquiring the required technologies and information to sustain and grow their businesses (Leboea, 2017; Du Plessis, 2012). This is because SMEs use low technology in their production as they cannot afford to acquire advanced technologies compared to bigger firms (Olawale & Garwe, 2010; Leboea, 2017). Manufacturing companies that are still growing lease technology and patents from foreign companies as it is difficult to obtain licenses from local companies (Abor, 2010; Leboea, 2017). Furthermore, the lack of skilled managers, who have the correct knowledge, has led to some companies investing in incorrect technology (Leboea, 2017). Another study has further argued that the lack of Information Communication Technology (ICT) skills in SMEs remain an area of concern as this is the differentiating factor in terms of profit (Gono, 2014; Du Plessis, 2012). Research has revealed that SMEs do not employ qualified technical people and this results in the company having to rely on external ICT service providers (Gono, 2014; Abor, 2010).

Previous research highlighted that the level of education of the owner has a direct impact on the adoption of technology (Gono, 2014). Another author, Howell et al. highlighted that ICT is considered an important contributor to economic development by reducing information costs and increasing participation (Howell, Van Beers & Doorn, 2018). SMEs face multiple barriers that make it difficult for them to advance in their technological capabilities (Du Plessis, 2012; Abor, 2010). Leboea (2017) cited Ngwenyama and Morawczynski, who argued that the barriers that hinder small-medium businesses from advancing with technology include; the lack of knowledge of the strategic use of technology, the lack of necessary skills base, the perceived high cost of setup, and geographic factors, amongst others.

2.3.3 Lack of finances

Access to funding is one of the biggest challenges that South African SMEs face (Chiu.Y, Chen.Y, Chiu.S., 2019; Du Plessis, 2012). The authors further argued that the lack of finance not only hinders growth but also decreases the chances of survival of the SME. The above will neutralise the ability of SMEs to realise their full potential as great contributors to the alleviation of poverty and unemployment (Abor, 2010; Leboea, 2017). Manzanai (2012) reported that there is a massive difference between the funds that the SMEs require and the supply from the financial institutions. In a South African context, there are many SMEs that are self-funded by individuals, who were previously disadvantaged, and hence a business can only grow to the capacity of the owner (Leboea, 2017). Despite the promising potential in fostering finances into SMEs, Manzanai (2012) argued that credit was not enough to fund small businesses but other means such as venture capital and equity finances should be considered. According to several studies, it has been noted that in terms of credit rationing, previously disadvantaged groups have limited resources (Manzanai, 2012). The financing gap, frequently defined as the difference between the demand by SMEs and the supply of funds by financial institutions, occurs for a number of reasons. Some argue that the fundamental reasons behind the lack of access to funding can be as a result of SMEs peculiar characteristics, whilst some argue that it is because of the market imperfections on the supply side (Leboea, 2017).

A substantial number of authors in their studies have attempted to draw compelling conclusions on the matters related to credit rationing (Green, 2003)(Mookherjee and Ray, 2015). One of the notable contributions was by Green (2003), who argued that banks were reluctant to offer finances to small businesses, due to the following reasons: high administrative costs for small loans, asymmetric information, high risk perception and lack of collateral. For SMEs to increases their profitability, the correct resources must be acquired to enhance processes such as production (Pradhan & Agwa-Ejon, 2018).

The ICT infrastructure is one of the main contributors to the shape and growth that a business will take (Du Plessis, 2012). However, the literature highlights that finances are the biggest challenge faced by small business that prevents them from acquiring the necessary technology (Pradhan & Agwa-Ejon, 2018; Moester, 2017). Qeshmy.D, Maksisi.J, Ribeiro.E, Angelis.J., (2019) highlighted concerns that other industrial companies may want to capitalise on this opportunity and invest resources and time. However, if it does not give the expected return on investment, it will place the business at danger of suffering losses or even closing down (Qeshmy et al., 2019). The projected investment that the German industry will invest was estimated at 40 billion euros annually for three (3) years (Moester, 2017). Very few of the SMEs would be able to afford to invest such amounts of capital as the return on investment would not be immediate (Moester, 2017). If an industry invests on the smart production, the organisation will have to increase production to qualify for the investment (Moester, 2017; Pradhan & Agwa-Ejon, 2018). However, without sufficient demand for the products, the organisation that has invested in the technology is at a risk of making a loss. Lack of adequate finances is already a challenge in many South African SMEs as they do not have access to appropriate credit and equity (Abor, 2010).

2.3.4 Labour unrest

Human capital has been defined as the commitment, attitude, values, experience, capability and skills that assist the business owner to have the business run efficiently (Kunene, 2008). Human capital is one of the elements that determines the survival and growth of the business (Kunene, 2008). The industrial action by workers has a disastrous effect on businesses (Williams, 2017). There are many reasons such as low pay, inequality, and unemployment as a result of union conflicts (Williams, 2017). Labour unrest is another hindrance to the growth of the economy and businesses (Williams, 2017; Du Plessis, 2012). The efficiency of production is negatively impacted and this can further scare off investors (Williams, 2017). According to Pulse (2007) quoted by Williams (2017) revealed that strikes lost 15% of the entire production during a 41-day labour unrest. SMEs might not have the luxury to remain in business if labour unrest continues for extended periods of time. SMEs are confined by the labour laws of South Africa and these include the minimum wage regulations, which they have to adhere to (Olawale & Garwe, 2010).

2.3.5 Cost of technology

Bringing value to end customers is one of the leading challenges for businesses in emerging markets (Howell et al., 2018). The weak economy has led many small businesses to bring forth innovations that will add value to their processes without having to spend large amounts of capital (Howell et al., 2018). Previous literature has revealed how SMEs are able to create value from nothing, unlike the belief that financial resources are hindering the success of SMEs (Hoegl, Gibbert & Mazursky, 2008). However, even with the creative ability that small businesses can utilise, there are certain limitations that will be experienced as small businesses are unable to invest as much as larger organisations in research and development (R&D) (Lee.K, Go.D, Park. L, Yoon. B, 2017).The use of smart technology and robotics may be limited, due to the costs of the technology (Pradhan & Agwa-Ejon, 2018). Manufacturing technology provides tools that allow production of different products. Common manufacturing technology includes computer-aided design (CAD), and computer-aided manufacturing, and assembly and test systems to assemble and test the product (Singh, 2006). The use of these techniques results in increased productivity, greater accuracy and flexibility, and reduced manufacturing costs (Singh, 2006).

According to Marie (2018), the initial cost of the computer-aided manufacturing software ranges between $5000 to $30000, dependent on the features and capabilities. There are hidden costs that are not highlighted to buyers such as the training of the employees and software updates (Marie, 2018). Larger companies can afford to ignore these costs but SMEs may have to abandon the adoption of such technology until there is enough capital to invest in the technology (Marie, 2018; Abor, 2010). The cost of technology has been an obstacle to the growth and development of small businesses in South Africa and similar countries (Abor, 2010; Pradhan & Agwa-Ejon, 2018). There has been an observed interest among South African manufacturers to adopt smart factories however, the old infrastructure will need upgrading, which will require a substantial sum of money, which may be a hindrance (Pradhan & Agwa-Ejon, 2018). On the contrary, smart technology may offer SMEs lower costs to their operation in the long run, yet the initial cost is high (Pradhan & Agwa-Ejon, 2018).

2.3.6 Market accessibility

The political instability in neighbouring countries, such as Zimbabwe, has forced businesses to seek better opportunities in South Africa (Kunene, 2008). This has caused an increase in competition for the SMEs as now there are more services and products (Kunene, 2008). Furthermore, few SMEs are able to secure prime locations as such places are high costs. The location has a great impact on the market and growth opportunities (Olawale & Garwe, 2010). SMEs find it difficult to compete with larger organisations that have greater financial backing and can afford better opportunities (Serei, 2016). There is limited research focused on emerging markets, which is often characterised by a lack of finances (Ray & Ray, 2010). Many small businesses lack this infrastructure and this leads to geographically fragmented markets, hence the cost of servicing the SME markets and being served by an SME becomes high (Ray & Ray, 2010).

Another advantage that big businesses in developed markets have, is the ability to easily sell their products to emerging markets by converting the currency to the local currency (Ray & Ray, 2010), whilst SMEs do not enjoy that benefit (Abor, 2010). One of the greatest concerns is the lack of institutional structures that makes it difficult for small organisations to protect and enforce intellectual property rights in many markets, thereby limiting the ability of the small businesses to invest in larger markets that require another mode of operation (Ray & Ray, 2010).

2.3.7 Lack of government support

Despite the potential and the impact that SMEs have on unemployment, SMEs still struggle to receive the required support from the government (Du Plessis, 2012; Abor, 2010). Although the attempt by the government to assist the population that was previously marginalised has shown fruit, the SMEs are still in need of government support (Shava, 2017)(White, 2005). The South African government’s policies have done very little to support business owners to start and grow their businesses as the awareness of the government’s support schemes remains unheard of (White, 2005; Olawale & Garwe, 2010).The BEE in South Africa has not been able to ignite the much needed transformation in small businesses and has resulted in lack of trust (Shava, 2017). Countries, such as India, have long supported small business by implementing policies such as a reservation policy for manufacturing of certain products (White, 2005).

The initiatives and policies that the government has put in place are not supported by legislation and therefore, cannot be easily enforced (Serei, 2016). Serei (2016)further highlighted that the government support processes were lengthy and unclear. The research went on to reveal that government does not have competent associates, who have the knowledge and required business experience to give the needed support (Serei, 2016). One of the greatest challenges that has frustrated SMEs, is the delay in payment for the services that have been provided and this is a result of the perceived corruption (Serei, 2016). There is however, a contradicting argument by Pradhan and Agwa-Ejon (2018), who stated that the government has a sound policy framework on technology, and research and development. The authors further revealed that there is an e-strategy that the government has set in place to cater for the innovation at hand. Some of the efforts that have been made by the government to support small businesses, such as small enterprise development agency (SEDA), have not been properly communicated to the businesses that are in need of the assistance (Olawale & Garwe, 2010).

Despite all these challenges that SMEs are facing, these businesses have been able to use what they have to compensate for what they cannot afford (Baker & Nelson, 2005).

2.3.8 Inadequate skills and training.

The constraints of SMEs include the inability of the organisations to attract and maintain skilled individuals, who are often expensive that cannot be afforded by most SMEs (Ahmed, 2013). The lack of skilled individuals can result in a lack of documentation of processes that result in making it difficult for newcomers to adapt to the company environment (Ahmed, 2013). The ability of SMEs to have adequate skills is the necessary element that will move the company forward and allow it to grow (Leboea, 2017; Olawale & Garwe, 2010). South Africa has a shortage of skilled individuals and hence the larger organisations, which are able to pay better, tend to attract the skills that are in demand (Leboea, 2017). Skilled employees according to the South African Department of Labour defined scarce skills as a shortage of qualified and experienced people. (Leboea, 2017; Olawale & Garwe, 2010). The level of education of the employees in a company directly impacts the workforce issues that are faced by an organisation (Du Plessis, 2012).

Furthermore, organisations that want to see growth have to be continually upskill employees (Pradhan & Agwa-Ejon, 2018). South Africa has many labour intensive industries with employees that are lowly skilled and will, therefore, face challenges to work with advanced machines and robotics (Pradhan & Agwa-Ejon, 2018). Besides the well-educated professionals, including the IT specialists and data analysts, there is still a great shortage of skilled manpower in the area of CPS (Pradhan & Agwa-Ejon, 2018).

2.4 Industry 4.0 opportunities

The above has highlighted that it is clear that there must be a means to mitigate all these challenges faced by the manufacturing industry. The progression of digital technology has caused more people to be connected to the web and to the global system (Pradhan & Agwa-Ejon, 2018). The digitisation of processes has allowed for the physical world to be driven by virtual means (Szozda, 2017). Developed economies have already begun with the integration from a manufacturing-based economy to an innovation-based economy (Gidlund. M, Han. S, Jennerhag. U., 2018). The advancement of information technology has and continues to change the economic landscape in Africa by creating opportunities for innovation (Howell et al., 2018).

The adoption of the Fourth Industrial Revolution will allow a business the ability to trade globally, thereby enabling even small businesses to compete in global markets (Pradhan & Agwa-Ejon, 2018). Furthermore, smart factories will increase production systems, which will result in better optimisation of the processes (Pradhan & Agwa-Ejon, 2018). Moreover, Pereira and Romero (2017) also added that Industry 4.0 will be the main driver in innovation, which will result in greater competitiveness. The economy will grow as this technology will bring producers and consumers closer, allowing for better and quicker exchange of ideas and relevant concepts *(Moktadir et* *al.*, 2018). However, there will be the unintended consequences of Industry 4.0 on the economy as the global value chain of outsourcing jobs will move from under developed and developing countries to developed economies, as they will be the ones who have the capital and the skills required to make this technology a reality (Moktadir. M, Ali. S, Kusi-Sarpong. S, Shaik., 2018). In addition, smart systems allow for the integration of information at several levels and can improve different business models that can be converted from potential business opportunities to realised businesses (Alexandre, 2014).

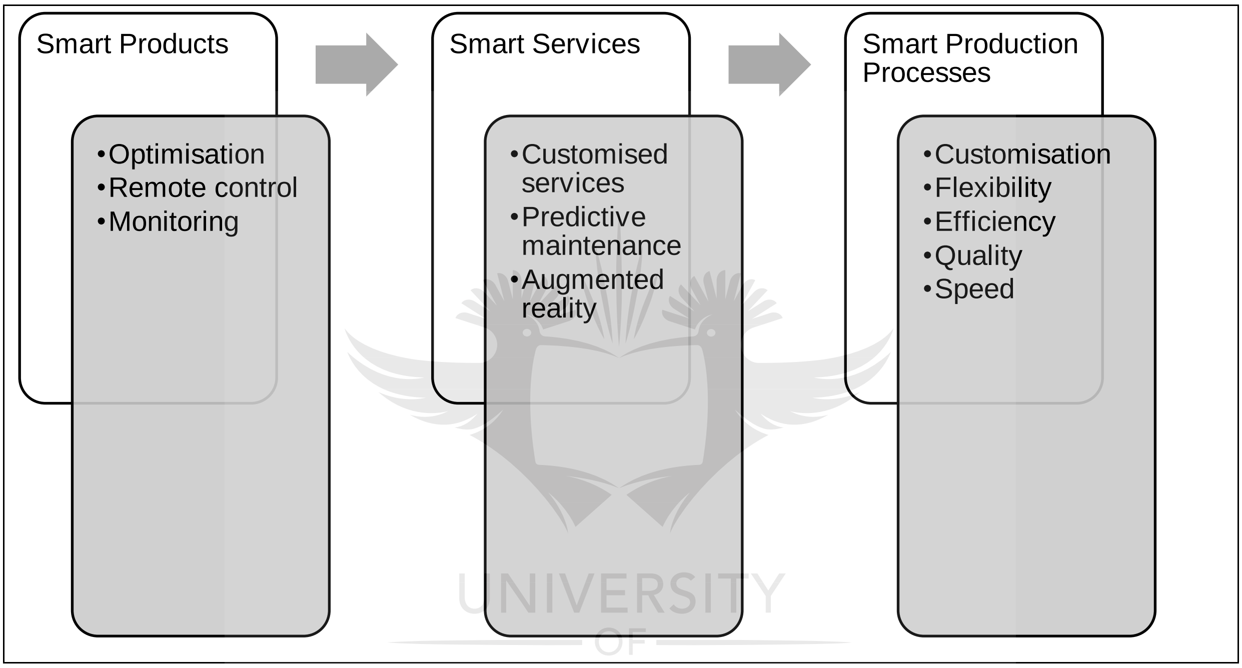

Figure 2.5 Overview of the benefits of Smart Industry

2.4.1 Smart production

The simple principle of Industry 4.0 is that machines must be smart and connected to the entire value chain of the workflow systems (Sung, 2018). A typical example would be a machine being able to predict failure, thereby triggering a maintenance process. This will result in the production process not being negatively affected (Szozda, 2017). There are four major mechanisms in Industry 4.0 that will have a major significance on productivity (Hercko, Slamkova & Hnat, 2015): i) A radically short product development process. The speed at which innovations are moving is forcing many organisations to compress their product development process as the product life has been shortened. Industry 4.0 allows for technologies, such as machining concepts that assist to minimise the length of development time; ii) Virtual engineering of complete value chains. A virtual value chain allows for better transparency where bottlenecks in workflow can be easily detected; iii) Revolutionary short value chains. The demand for customised products has increased and with Industry 4.0 machines, they have the ability to produce different variations of the same product. The combination of artificial intelligence and production machines saves unproductive times, thereby increasing productivity; iv) Better performing than engineered. Lastly, fully automated productions reduce the activity burden and introduce working more efficiently.

Self-learning machines have high flexibility and are very reactive to abrupt changes in the production plan (Wang. S,Wan. J, Li. D, Zhang. C., 2016). Multiple authors have agreed that the benefit of smart production cannot be ignored (Shrouf, Ordieres and Miragliotta, 2014)(Davies, 2015). Moester (2017) agreed by further highlighting the benefits, such as monitoring, controlling, optimisation, and autonomy. Moester further indicated that the data that the machinery is able to gather can be used to monitor patterns. The control is enhanced by the product having the ability to be remotely controlled through cyber physical systems. In addition, the optimisation occurs when the manufacturers are able to optimise the product performance, efficiency and service. Kusiak (2019) agreed that there will be benefits of smart manufacturing. The above author described that smart manufacturing, though not exhaustive, has six pillars, which include materials, data, predictive engineering, sustainability, resource sharing and networking, manufacturing technology and processes. The growing use of data will allow for smart manufacturing to deliver value (Kusiak, 2019). Another notable contribution of smart production is resource sharing, this may include machine sharing and transportation as machines will now have multiple uses (Kusiak, 2019). Equipment monitoring, diagnosis and repair autonomy remains one of the leading benefits of smart manufacturing as the machines will have the know-how of predicting faults and therefore, better preparation will be put in place and this will support value delivering to the customers (Kusiak, 2019).

2.4.2 Skilled workforce and employment

The advancement of technology has left many people feeling uneasy because of the fear that a machine will replace humans (Pereira & Romero, 2017). The advancement of cyber physical systems will definitely cause disruptions in the labour market.

However, the migration of the labour force is dependent on the technical feasibility rather than occupations (Gidlund et al., 2018). There has been a concern that robots will replace humans, however automation will complement humans to improve efficiency and reduce certain safety concerns (Pradhan & Agwa-Ejon, 2018). The structure of the South African economy relies on labour intensive industries and a large number of the workforce is low skilled or semi-skilled (Kergroach, 2017). This therefore, means that the current industries need to change and improve their way of working by upskilling and training their workforce (Pradhan & Agwa-Ejon, 2018). The country still has a shortage of experts in the area of CPS, thereby opening employment opportunities and training for the workforce, who will assist in the deployment and integration of Industry 4.0 (Pradhan & Agwa-Ejon, 2018). However, Davies (2015) predicted that there will be a shortage of skilled labourers as most manufacturing plants do not have the human skills required for the sophisticated smart machines. Davies further argued that without the right skills, this will be the obstacle to deriving the full value from Industry 4.0. (Davies, 2015)

2.4.3 Energy efficiency

Energy consumption is commonly a notable cost in any manufacturing plant, however, with many of the applications of the Internet of Things relying on batteries, energy will be used more efficiently (Gidlund et al., 2018). The Industry 4.0 IoT leverages on miniature devices that transmit and transfer data through the means of wireless communication (Lekidis & Katsaros, 2018). These devices are normally small and have a low energy consumption and supplied with batteries (Lekidis & Katsaros, 2018). Energy efficiency is important in the quest to reduce manufacturing and operational costs as well as the impact on the environment (Ang. J, Goh. C, Saldivar. A, Li. Y., 2017). The energy efficient designs have to be complemented by an energy efficient operating (Gidlund et al., 2018). Green networking is a process of selecting energy efficient technologies and products, and minimising resource-use to lessen power consumption (Gidlund et al., 2018). Green networking is one of the technologies that uses low power by means of star topology, which eradicates the energy consumed through packet routing in multi-hop networks (Gidlund et al., 2018). The use of narrowband channels that reduce the noise level and extend the transmission, is another means to reduce energy consumption (Gidlund et al., 2018). The challenge that faces manufacturing plants to determine and monitor the energy consumption of all the individual machines is how to have control measures and improve overall energy efficiency (Ang et al., 2017). This can be achieved with the smart sensors and forecasting tools. The smart systems are able to monitor the facility's energy use at peak and off-peak periods using smart energy management systems (Ang et al., 2017). Automated simulations can be done in such a manner to optimise energy consumption by altering the machine operating schedule or providing an estimation of energy consumption for new facilities (Ang et al., 2017). Lekidis. A, Katsaros. P. (2018) cited Dunkels et al., who introduced a software based solution, which works through a power trace module. The power trace device allows for the analysis of energy consumption at network level and can be used by multiple kinds of IoT devices (Lekidis & Katsaros, 2018). However, the limitation of the software is that it cannot measure the energy consumption for the device communication that is connected with the peripherals such as sensors (Lekidis & Katsaros, 2018). Furthermore, the machines and technology used in Industry 4.0 are also considering energy harvesting (Gidlund et al., 2018).

Energy harvesting is the process of capturing and accumulating the energy that is produced as a byproduct of another process and storing it for later use (Monitor, 2017; Gidlund et al., 2018). This will have a positive impact on a country like South Africa that is already having challenges with energy levels. The benefit that this type of energy has over batteries as a source of energy is that batteries have a limited life span. If a system has thousands of batteries, it may be costly (Monitor, 2017). There is however, a threat that is posed by energy harvesting devices as they do not have a substitute device (Monitor, 2017). According to Moester (2017), the digitisation of products and their production process becomes more efficient due to the intercommunication between the machines, raw material and products, which allow for better communication. Through the design and operation of smart manufacturing plants, it is envisioned that energy efficiency will greatly improve (Ang et al., 2017).

2.4.4 Smart economy

The adoption of the Fourth Industrial Revolution will allow businesses to trade globally, thereby enabling even small businesses to compete in the global markets (Pradhan &

Agwa-Ejon, 2018). Furthermore, smart factories will increase production systems, which will result in better optimisation of the processes (Pradhan & Agwa-Ejon, 2018). Moreover, Pereira and Romero (2017) added that Industry 4.0 will be the main driver in innovation, which will result in greater competitiveness. The economy will grow as this technology will bring producers and consumers closer to each other, thereby allowing for a better and quicker exchange of ideas and relevant concepts (Moktadir et al., 2018). Countries that have already implemented a data-driven supply chain are able to speed up manufacturing process by 120% and improve delivery of orders by 70% (Bahrin et al., 2016). The benefit of businesses adopting technology is that information technology (IT) applications are often considered important promoters of economic development by reducing the information costs, promoting innovation and increasing inclusion (Howell et al., 2018). Industry 4.0 will have amongst others, two possibilities listed below that are highlighted in the study done by Howell et al. (2018) The first possibility is the creation of new and low-cost innovation, due to the equal access of information and the simplicity of investing, which will result in the increase in the economic development. The second possibility is the new business models that allow low-cost innovation of economic development (Howell et al., 2018). The smart economy includes the concept of sustainability, such as the circular economy. The circular economy is the closed-loop supply chain, which is focused on restorative and regenerate aspects, which allows the industrial system to restore when it reaches the end of life (Rajput and Singh, 2019). This eliminates wastage by intentional design models, materials and systems that can be reused (Rajput & Singh, 2019). The profitability of companies will increase as the materials and efficiency used will have cost reduction implications, which will have a positive impact on the profit margins (Rajput and Singh, 2019). Furthermore, the use of environmentally friendly material can be used as a marketing campaign to attract more customers (Rajput & Singh, 2019).

The world economic forum stated that there are three billion people who now have access to mobility and this number is growing by 10% year-on-year (Tassel, 2019). The e-commerce market has grown globally by 18% and businesses that are participating in e-commerce grew by 30%, which amounts to 4.5 billion dollars (Tassel, 2019). With manufacturers, suppliers and customers being on the same ecosystem, this shortens the delivery times and allows for flexible customisation of products(Tassel, 2019); Rajput & Singh, 2019). However, there will be the unintended consequences of Industry 4.0 on the economy as the global value chain of outsourcing jobs will move from under-developed and developing countries to developed economies as they will be the ones with the capital and the skills required to make this technology a reality (Moktadir et al., 2018).

2.4.5 Real-time performance

One of the notable benefits of Industry 4.0 is the ability to have real-time information (Rajput & Singh, 2019; Gidlund et al., 2018). The real-time data will assist with accurate forecasting as the machines are smart enough to communicate efficiency levels (Bahrin et al., 2016). The tracking of the process further improves the quality of the products produced (Harrison et al., 2016). The improvement is an outcome of the machines being able to communicate if there are any faults that might affect the quality of the product (Wang *et al.*, 2016) Furthermore, the introduction of cloud computing will give customers better visibility of the process and how far the product is from being delivered (Ibarra, Ganzarain & Igartua, 2018). The transparency will give the customer a better understanding and insight, which will allow for better customer interface (Ibarra et al., 2018). Lastly, the real-time metrics allow for organisations to plan better for maintenance and ensure that the machines are always performing optimally (Shah. B, Faheem.M, Butt.R, Raza R, Anwar. M, Ashraf M., 2018). Industry 4.0 supports the overcoming of barriers that result in delays in the supply chain (Rajput & Singh, 2019). The more devices that are embedded with computing technologies and more intercommunication between these, allowing for centralised controlling and promotion of decentralised analytics and decision-making, will have an outcome on real-time responses (Bahrin et al., 2016). The simulations will leverage real-time data to reflect the physical world with the virtual and this allows operators to test and optimise the machine settings for the next product to be manufactured (Pradhan & Agwa-Ejon, 2018; Bahrin et al., 2016). This will enable precise and live measurements of the performance of the production line (Du Plessis, 2017).

2.4.6 Product flexibility

Customers demand more customisation of products and with Industry 4.0, there is provision this (Bahrin et al., 2016). The ability for smart machines to do product changes with minimal intervention and self-configuring equipment allows for quicker customisation (Santos.C, Mehrsai. A, Barros. A, Araujo. M, Ares. E., 2017). Smart manufacturing uses data from multiple sources, such as customers and designers, this then allows for better forecasting (Santos et al., 2017). SMEs, with the use of this technology will be able to quickly scale up or down a certain product as per market demand (Hercko et al., 2015). Furthermore, the implementation of smart manufacturing enables organisations to respond to personalised products without altering the price of the product *(Santos* et al., 2017). Mass customisation is one of the elements that SMEs can use as a competitive advantage to get ahead of big corporates (Kanama, 2016). When customers are involved in the design stage of the product, it improves the quality, and customers will need to pay higher prices if it meets their needs (Kanama, 2016).

Having product flexibility increases sales, as there can be products that are customised for certain geographical locations that are different to others (Kanama, 2016). South African manufacturers already have high regard for customisation and customer specific services however, these services are currently provided at higher prices (Pradhan & Agwa-Ejon, 2018). The manufacturing industry has implemented flexible manufacturing yet there is an opportunity for those manufacturers to move towards mass customisation (Pradhan & Agwa-Ejon, 2018). South African entrepreneurs have seen the gap of using and embracing technology as a way to receive feedback, which will enable them to better manufacture their products (Pradhan & Agwa-Ejon, 2018). Product flexibility will assist in building an economy and social system that can respond to the changes in a flexible manner (Sung, 2018).

2.4.7 Other benefits

The use of smart technology will have a positive impact on product and resources traceability as the system allows for transparency (Ibarra et al.m, 2018). There will be further value that will be derived from employees having the flexibility to work from anywhere, which will increase the speed of communication and knowledge exchange

(Ibarra et al., 2018). Table 2.2 highlights the challenges that were identified in Section 2.3 by comparing them to the opportunities that Industry 4.0 will provide.

Scientists and researchers are deadlocked as there are certain problems that science and technology cannot resolve. Human behaviours cannot be solved by technology unless there is human modification (Church, 2015). However, some scientists believe that technology can solve any problem (Johnston, 2018). Corruption does not start and end with bribery but is started by workers being dishonest, such as time management of lunch breaks (Singh, Chetty & Karodia, 2016). Crime and corruption, and labour unrest are some of the challenges that the findings in the literature do not provide a solution to.

When Table 2.2 is analysed, it is evident that some of the challenges that are experienced by small manufacturing businesses can be solved by the adoption of smart manufacturing. Table 2.2 indicates that smart production will solve a notable number of challenges. In addition, a skilled workforce is a major contributor to the challenges that SMEs are facing. Another benefit that has been widely agreed on is improved quality (Moester, 2017). The ability of the machines to communicate and share data allows for major quality improvements (Moester, 2017).

Table 2.2 Summary of Industry 4.0 opportunities

	Crime and corruption	**Lack of ICT capabilities**	**Labour unrest**	**Cost of technology**	**Market accessibility**	**Lack of finances**	**Lack of government support**	**Inadequate skills and training**
Smart production		(Howell et al., 2018)			(Gidlund et al., 2018) (Kergroach, 2017) (Müller, Buliga & Voigt, 2018)	(Pradhan & Agwa-Ejon, 2018) (Hercko, Slamkova & Hnat, 2015)		
Skilled workforce			(Kergroach		(Pereira & Romero, 2017)	(Hercko, Slamkova & Hnat,	(Pradhan & Agwa-Ejon, 2018)	(Rooney, Heuvel & Lorenzo,

			, 2017)			2015) Szozda, 2017)		2002) Kergroach, 2017)
Energy efficiency				(Kergroach, 2017) (Ang et al., 2017) Lekidis & Katsaros, 2018)	(Abor, 2010)			
Smart economy		(Rajput & Singh, 2019)			(Pereira & Romero, 2017) (Rajput & Singh, 2019)	(Alexandre, 2014) Hercko, Slamkova & Hnat, 2015)	(Pradhan & Agwa-Ejon, 2018)	
Real time performance					(Harrison, Vera & Ahmad, 2016) (Ibarra, Ganzarain & Igartua, 2018)	*(Wang* et al., *2016)* *(*Pradhan & Agwa-Ejon, 2018)		
Product flexibility				(Kanama, 2016)	(Kanama, 2016) (K. Santos et al., 2017)			
Other benefits					(Ibarra, Ganzarain & Igartua, 2018) (Moester, 2017)			

2.5 Conclusion

The above section was aimed at providing an understanding of the current status quo from the available literature. From the literature, the challenges that manufacturing SMEs face in South Africa, were explored. One of the findings was that slow production is one of the biggest contributors to the failure of many businesses.

This section further explored the opportunities that Industry 4.0 provides with the use of smart manufacturing, Internet of Things and a cyber physical system. These improvements in production were seen to have a positive impact on the overall business however, the cost of implementing some of this technology was highlighted as a major obstacle. It was found that if this technology is implemented, organisations will have better global market accessibility, and this will increase the profits and business growth. This further highlighted the significance of technology in the success of small businesses. The literature has given a basis for each of the research questions, the next section will utilise the gathered knowledge and investigate the use of data that will be collected from manufacturing SMEs. The next chapter is aimed at proving or disqualifying the literature as applied in a South African context.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The purpose of this research was to assess the potential impact that Industry 4.0 would have on South African SMEs. Upon formulation of the research problem, the following questions were developed:

- What are the challenges that SMEs are facing?
- What opportunities does Industry 4.0 provide for the manufacturing processes of SMEs?

Data was collected to address the research questions listed above. The aim of this chapter was to describe the method and tools used to collect data that would address the research questions. Once the data was collected, it was analysed to determine if it proved the literature or provided a different outcome when compared with past literature that was discussed in Chapter 2.

3.2. Research Design

According to the literature, there are multiple research methods that can be used and these include qualitative, quantitative and mixed methods. Each of these methods employs different techniques that are used to collect data. Hoestee (2006) in their book “Constructing a good dissertation” and Mauch and Park, (n. d.) in their book "Guide to a successful thesis and dissertation”, all the authors outline different techniques that can be employed (Mauch and Park, 2003). Table 3.1 below indicates the different methods that can possibly be used during research.

Table 3.1 Research Methods (Mauch and Park, 2003)

Research Method	Definition
Exploratory research	This method investigates new or relatively unknown territory for the purpose of scrutinising the phenomena to lead to a better understanding.
Case study	This method uses the background, development, current condition and environmental interactions of one or more individuals, groups or business to observe patterns and influences.
Descriptive research	This is a correlation-based method that can either be qualitative or quantitative. The descriptive method correlates data between two or more variables
Mixed method research	The mixed method includes both qualitative and quantitative data through a process of combination to get a better understanding of the problem
Action research	Action research is a method that generally looks at the process changes by collecting data relevant to the problem

Table 3.2 indicates the different techniques that can be used to collect the relevant data required for the research process.

Table 3.2 Data Collection Methods

Data collection method	Definition
Interviews	Interviews entail the process of gathering data regarding the research problem by asking for participants' responses to questions asked. Interviews can either be structured or unstructured and can be completed face-to-face or remotely
Observation	Observation can be done through observing, recording, and interpreting the events. This method of gathering data can be controlled or uncontrolled, participant or non-participant, structured or unstructured and lastly concealed or unconcealed.
Questionnaire	A questionnaire is a preset group of questions that are used by the respondents to record their feedback. Questionnaires are mainly used when the research is descriptive or explanatory. Questionnaires can be self-administered or administered electronically.

This research used a descriptive research method as the preferred choice and employed questionnaires as the primary means of data collection as indicated in Table 3.2. The motivation to use questionnaires was that a large population in multiple locations can be reached at a relatively low cost. The study was a quantitative study and collected data about small to medium enterprises in the manufacturing sector. The research only focused on identifying the challenges faced by SMEs, to identify the opportunities that makes Industry 4.0 available to the manufacturing sector.

The descriptive method is best suited for topics that might not be easily quantifiable. The method allows for observations in natural settings. The benefit of using questionnaires was that the results would be practical, the respondents could be from different parts of the country and feedback could be achieved within the specified time limitations.

3.3 Research Methodology

In a quest to address the research questions at multiple levels, it was vital that the research was done from a descriptive perspective. Descriptive research would assist in highlighting the amount of knowledge that small businesses have on the new technology of Industry 4.0.

Through observations and informal discussions with participating SMEs, it was confirmed that their businesses face similar challenges that were highlighted by the literature. This observation was conducted to validate and ensure that the challenges that were discovered from the literature were still relevant amidst the country's economic and political ecosystem. These informal discussions revealed that small businesses were seeking a means to reduce the impact that these challenges have on their businesses using technology to address these. Some of the business owners showed interest in what the international markets were involved in to solve some of the issues that were faced by entrepreneurs.

3.4 Data collection method

The data was collected in the form of structured online questionnaires. This technique was employed to extract insight from people within the organisations of what they thought were the challenges of SMEs. Questions to do with the challenges were highlighted and the respondents could indicate how much of an impact the challenge had on the business. The questions further sought to understand how much knowledge the businesses had with regards to Industry 4.0 and if they believed that it could mitigate some of the challenges that they were currently facing. The techniques and instruments that the researcher has selected have advantages and disadvantages, as shown in Table 3.3 below:

Table 3.3 Research Techniques: advantages and disadvantages

Research techniques	**Advantages**	**Disadvantages**
Questionnaire data	Inexpensive	Skipped questions
	Practical and standardised	Interpretation issues
	Validity and reliability	Dishonest responses
Descriptive method	Data collection	Confidentiality
	Practical experience	Objectivity and error

Manufacturing SMEs are not entirely the same, though there are similar challenges that might be shared. This, therefore, made it necessary to survey more than one company to obtain credible results. The literature revealed that the judgements given by non-experts were normally more accurate than the use of a single expert (Du Plessis, 2012). This research received responses from a 87 small business owners. The researcher collected data by means of a survey using questionnaires to business owners and managers.

3.5 Research Planning

The research focused on the challenges that were faced by manufacturing SMEs and how the technology of Industry 4.0 could possibly eliminate these.

3.5.1 Demographics

While demographics were not related to the primary focus of the research, it was critical to build a profile of the organisations that participated. This would enable the underlying trends from the data to be identified; for instance, determining how the size of the organisations affects and impacts the challenges the businesses face.

The demographics that were analysed were gender, the number of years in operation, location of the business, and their customers. These assisted in the analysis and understanding of how these demographics affected the challenges and how the opportunities could be flexible within the same environment

3.6 Data collection

Questionnaire design

The questionnaire was used to collect primary data relevant to the research questions and objectives. The questionnaire was designed to ask a limited number of questions using a scaling method to rate the responses of the interviewees. The reason why the questionnaire was preferred for this research was:

- Geographical flexibility, a larger area could be covered; and
- The respondents were able to complete the questions in their own time.

Figure 3.1 below shows the different methods of data collection. These included the different techniques used to collect data during the research. This is shown using diagram in Figure 3.1 below.

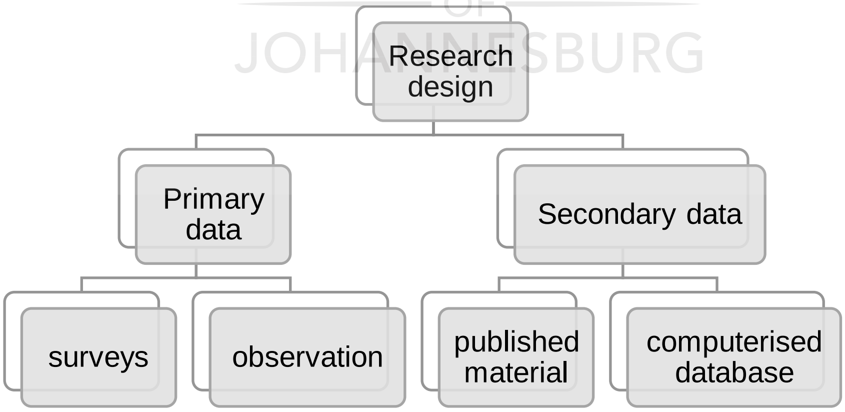

Figure 3.1 Types of Research Data

The secondary data that was collected included consulting previous literature. The secondary data was used as a guide for the collection of the primary data using questionnaires.

The primary data was collected first hand by the researcher using online facilities and this was compared to the secondary data. The benefit of using primary data was that it gave a balanced view of fact and perception. This allowed for the secondary data to be tested as it might have been collected under different economic and environmental ecosystems.

The questionnaire for this study was designed by the researcher. The questions were based on the factors identified as a proposition model. The questions were adapted from numerous literature sources (Du Plessis, 2012). The instrument used by Du Plessis (2012) had similar aspects and this would allow for a better comparison.

The questionnaire that was designed used several questioning techniques. The study employed a 5-point Likert scale, multiple choice questions, dichotomous questions, and single answer questions. A list of statements was presented to the respondents, who had to indicate the extent to which they agreed or disagreed with the statements.

For the above questionnaire design, Table 3.4 below was used as a guiding tool to ensure that the questions met the objectives of the study.

Table 3.4 Questionnaire design

Section #	**Question #**	**Literature reference**	**Purpose**
Section A	1- 7	Section 2.2	Determine and validate that the business was an SME
Section B	8	Section 2.3	Determine the challenges that were faced by the SMEs
	9	Section 2.1	Determine the production capability
Section C	10-11	Section 2.4	Determine the knowledge of Industry 4.0
	12	Section 2.4	Awareness of Industry 4.0
	13	Section 2.4	Determine the opportunities that Industry 4.0 brings to manufacturing businesses and

			further investigated the perceptions on Industry 4.0
	14	Section 2.4	Determine the barriers of implementing Industry 4.0
	15	Section 2.4	Perceptions of Industry 4.0

Table 3.4 was used to construct the questionnaire as the study aimed to identify the challenges that SMEs face (Section B). However, to ensure that the respondents were from SMEs Section A was included. The second objective was to determine the prospects of Industry 4.0 in the manufacturing industry (Section C) and to investigate the perception of the respondents of Industry 4.0.

3.7 Measuring Scales

The Likert scales were used to determine each participant's response to the statement listed. Table 3.5 below illustrates the three (3) types of Likert scales that were used.

Table 3.5 Four- and Five- point Likert scales (Joshi.A, Kale. S, Chandel. S, Pal. D., 2015)

Type	1	2	3	4	5
Type 1	To no extent	Small extent	Moderate extent	Large extent	Very large extent
Type 2	Not at all aware	Slightly aware	Somewhat aware	Moderately aware	Very aware
Type 3	Not a barrier	Somewhat of a barrier	Moderate barrier	Extreme barrier	-

The questionnaire used both a 4- and 5-point Likert scale to measure the extent the respondents agreed with the statements, the awareness levels, and lastly to the barriers. Type 1: a 5-point Likert scale with ranges from 1 – 5, where 1= to no extent, 2 = small extent, 3 = moderate extent, 4 = large extent and 5 = very large extent. Type 2 was a 5-point Likert scale used to investigate the level of awareness where 1 = not at all aware, 2 = slightly aware, 3 = somewhat aware, 4 = moderately aware and 5 =

very aware. The last was a 4-point Likert scale to test the extent of the barriers, where 1 = not a barrier, 2 = somewhat of a barrier, 3 = moderate barrier, 4 = extreme barrier.

3.8 Population sampling

There are more than two types of sampling methods that can be used to collect research data but the most frequently used being either probability or non-probability sampling. Both of these methods have different techniques based on the research being conducted.

Probability sampling is a method that is dependent on a random sample selection. This method should however, ensure that the elements in the population have an equal chance of being selected (Joshi *et al.*, 2015). Probability sampling has four techniques, which include random sampling, systematic sampling, stratified sampling and cluster sampling (Joshi *et al.*, 2015)

Non-probability relies on a researcher's personal judgement in deciding who will be included in the research sample (Joshi *et al.*, 2015) Non-probability sampling has four techniques that can be applied namely; reliance sampling, quota sampling, snowball sampling, and purposive sampling.

This study used a non-probability sampling method. This technique allowed the researcher to select the research sample based on the researcher's knowledge of the problem and the population. The benefit of using such a sample was its convenience to address the focal point of the study. The limitation of this sampling method is its subjectiveness.

A total of 100 participants were selected for the sample size, which was based on the research objectives. Table 3.6 below shows the sample, which included higher-ranking members of organisations, middle management and lower-level employees.

Table 3.6 Population sample

Focus area	**Sample size**
Top Managers (director/CEO, Senior manager)	40

Managers (manager, supervisor, team leader)	35
First line employees (specialist, researcher, general workers)	25

The participants of the sample listed in the above Table 3.6 comprised the following positions:

Top Management:

These are the people who are responsible for controlling and overseeing the entire organisation. They develop goals, strategic plans, company policies and make decisions pertaining to the direction of the business. These are individuals, who are able to track the progress of the business in terms of the financial impact and meeting the customer's requirements. Usually top management includes the business owners, who still have a responsibility of communicating the vision of the enterprise.

Top management was relevant for this study as these individuals and committees, make decisions as to whether an idea or technology will be adopted or not. Top management was crucial as they are aware of the impact improved efficiency will have on the entire business.

Middle management:

Middle management is responsible for executing organisational plans according to the company's objectives, goals and policies. These are the people who are responsible for designing and implementing intergroup work and information systems. They further diagnose and resolve the problems among the work groups. Middle managers also design and implement reward systems that support cooperative behaviour.

Middle management was relevant for this study as these individuals are aware of the bottlenecks in production. They would note an improved system to assist the company to better meet their production goals. Since they are also responsible for diagnosing problems, they are fully aware of the challenges that are faced by the organisation from an operational perspective.

First line employees

These are the people that perform tasks that have been assigned to them by management. These include operators, who ensure that machines are working optimally, to meet the orders. Furthermore, first line employees have the duty to receive the orders so that these, once placed, are manufactured. Most of the work that is done by first line employees is operational and they are hardly bothered by profit margins and company strategies.

First line employees' responses were relevant for the research as they do the physical work every day. They would be able to know, which procedures and operations need to be done more efficiently and how these would improve their day-to-day targets without compromising the quality of the product.

3.9 Research execution

The research was executed using methods: an online questionnaire using google forms. The reason for the use of an online questionnaire was for a wider coverage at minimal costs. The preliminary testing of the survey indicated that it took between 10 to 20 minutes to complete. The online survey contained a short introduction and background to the study. In some instances, there was an introductory email to the potential respondent to establish a rapport. Five days after the initial email, a follow-up email was sent to each respondent to remind them to participate.

3.10 Validity and Reliability

Validity and reliability were important to ensure that the study was trustworthy and the results were reliable. The questionnaire was reviewed by a statistician to make certain the questions were relevant for what the study was aiming to achieve. Furthermore, this was done to ensure that the questions would provide answers that responded to the objectives of the study. The questionnaire was pre-tested with four (4) respondents from SMEs. This was to validate if the questions were understandable and that no respondent would be uncomfortable completing the questionnaire. Lastly, the Cronbach's Alpha coefficient was used to test the reliability of the study.

3.11 Limitations

There were a few limitations from the data that was collected that might have possibly compromised the quality of the analysis and the findings:

- Data was collected mainly from companies in the Gauteng province;
- The responses of the operators and low-level employees might have been compromised by the lack of understanding, especially with the online survey;
- The respondents might have been biased in their responses not to reveal the practical and real answers to the questionnaire; and
- Top management might be in denial of the company status quo.

3.12 Conclusion

The main aim of this chapter was to outline the research method that was applied. The purpose of the research and the main objective was to ensure that the data collected was relevant and would provide correct findings. The reasons for the applied research methods were discussed, as well as the data collection instruments that were used. The advantages and limitations of the chosen methods and instruments were also discussed in detail. Chapter 4 presents the results of the analysed data..

CHAPTER 4: DATA COLLECTION AND ANALYSIS

4.1 Introduction

As introduced in Chapter 1, the objective of this study was to investigate the challenges that are faced by South African SMEs and to highlight the potential opportunities provided by Industry 4.0. To achieve this, a questionnaire was designed to obtain the required information. The purpose of this chapter is to present the results obtained from the questionnaire. This chapter provides an interpretation of the collected and analysed data. The analysis of the raw data was done using the Statistical Package for Social Sciences (SPSS).

Table 4.1 Summary of the questionnaire survey responses

Survey Responses	Respondents
Number of questionnaires distributed	100
Number of questionnaire returned	87
Number of useable questionnaires	87

Each of the questionnaires consisted of three (3) sections with a total of 15 questions. Of the 100 questionnaires that were distributed, 87 were returned. All the returned questionnaires were useable, which represented an 87% response rate. This satisfies the further analysis on the base set by Moser and Kalton (1971) (Kumar, 2011), which states that if the response is below 40%, the survey can be categorised as biased.

4.2 SMEs context of response

To get a better understanding of the research respondents and their respective needs and challenges, a number of demographic questions were asked to profile the responses. From the questionnaire, the researcher was able to determine the participating businesses across the different sectors, the locations and how they differed in size. The respondents included those from different positions in the organisations and the number of years they had been in business.

4.2.1 Years of business in operation

As illustrated in Figure 4.1, the category with the most responses for the number of years that businesses had been in operation, was that of 10 to 15 years, with a frequency of 25. This was followed by those with more than 20 years in operation with a frequency of 23. The third was the business that had been in operation between five (5) to 10 years with a frequency of 21. The least was 18 respondents in the category of less than five (5) years, which was 21%.

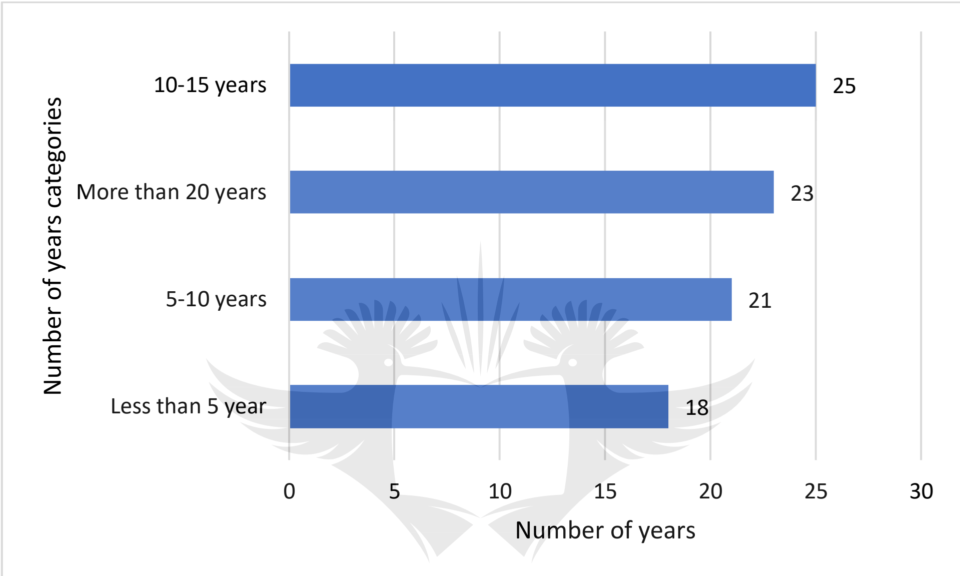

Figure 4.1 Number of years in operation

4.2.2 Number of people employed

Figure 4.2 shows the distribution of the sample in accordance with the number of people that were employed in the organisation. Most responses (44%) were from medium-sized companies. The second highest response (33%) was from small businesses, which were between 10 and 99 employees. Lastly, the micro organisation with the number of employees between one (1) to nine (9), was 18%.

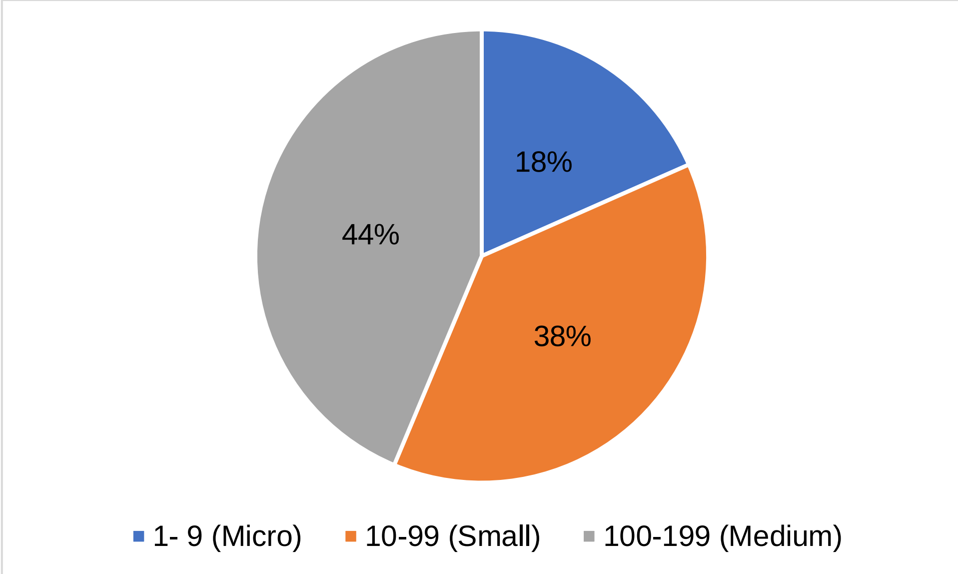

Figure 4.2 Number of people employed in the organisation

4.2.3 Business sector

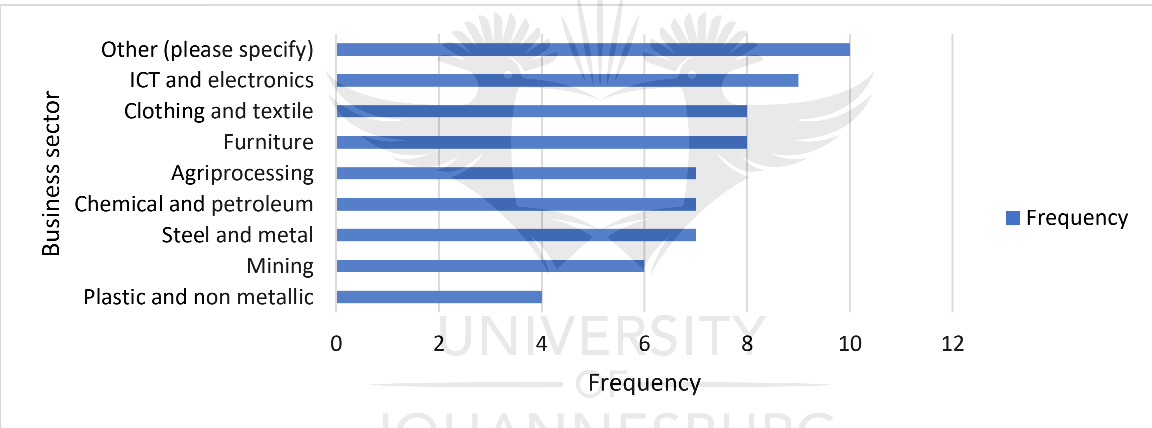

Figure 4.3 Business sectors of the organisation

Figure 4.3 shows the distribution of the participants in the manufacturing sector. Food and beverage had the most responses with 24%. The second highest number of responses was stated as 'other'. The manufacturing of ICT and electronics was the third highest contributor with a frequency of nine (9) (10%). Both clothing and textiles, and furniture had eight (8) responses (9%). Steel and metal, chemical and petroleum, and agriprocessing all had 7 responses (8%). The second least sector that participated in the survey was the mining sector, with 7%, which was the second lowest score. The sector with the lowest score was the plastic and non-metallic manufacturing sector with only 4 responses.

4.2.4 Channels of customer interaction

Figure 4.4 illustrates how the organisations interact with their customers. Most organisations with a response frequency of 41 which is 47% that participated in the survey indicated that they deal with the customers both face-to-face and virtually. Followed by a frequency of 37which is 43% where the organisation interacts with their company virtually. The lowest frequency was 9 which amounts to 10% of customer interaction was where customers had to physically visit the store .

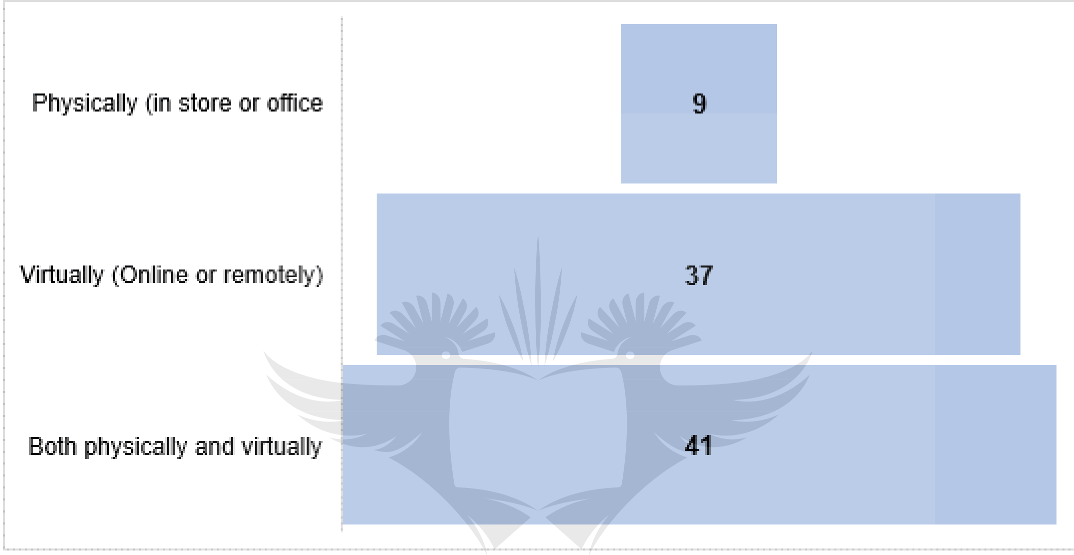

Figure 4.4 Channels of customer interaction

4.2.5 Major business location

Figure 4.5 illustrates the locations where the organisations do most of their business. With a total of 80%, most of the business was conducted in Gauteng and KwaZulu-Natal, which forms 20% of the total number of locations. The third was Mpumalanga with 16%. The rest of South Africa and Africa were both 8% and the least was 'other' locations with a frequency of three (3).

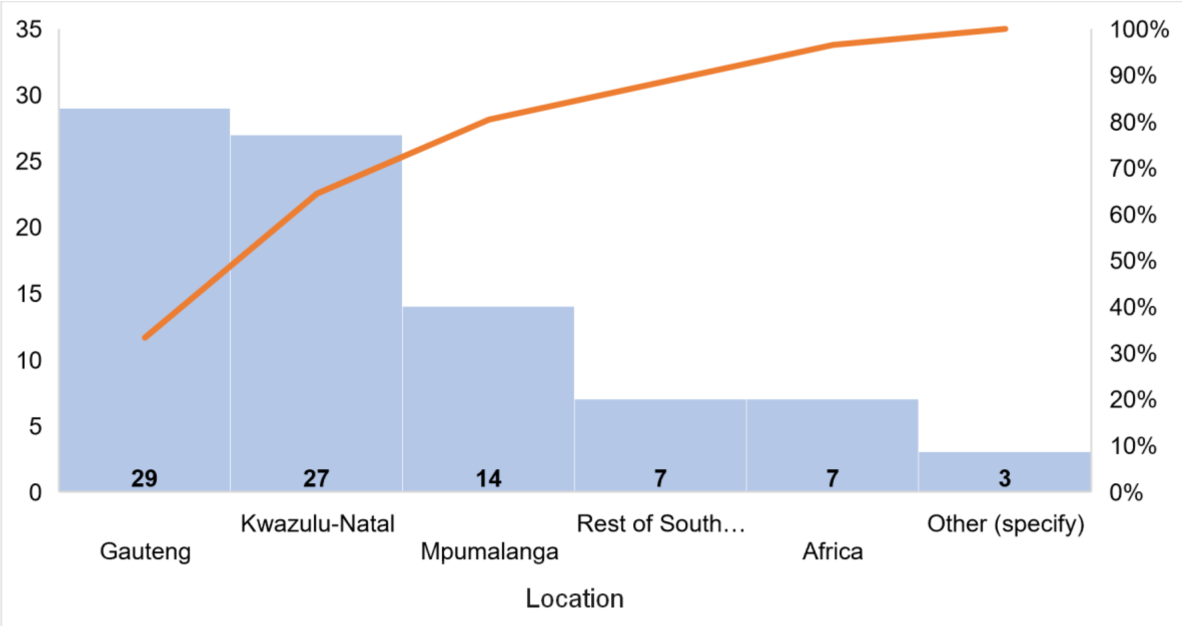

Figure 4.5 Major business locations of the organisations

4.2.6 Respondent profile

Figure 4.6 illustrates the distribution of the sample according to the respondents' occupations.

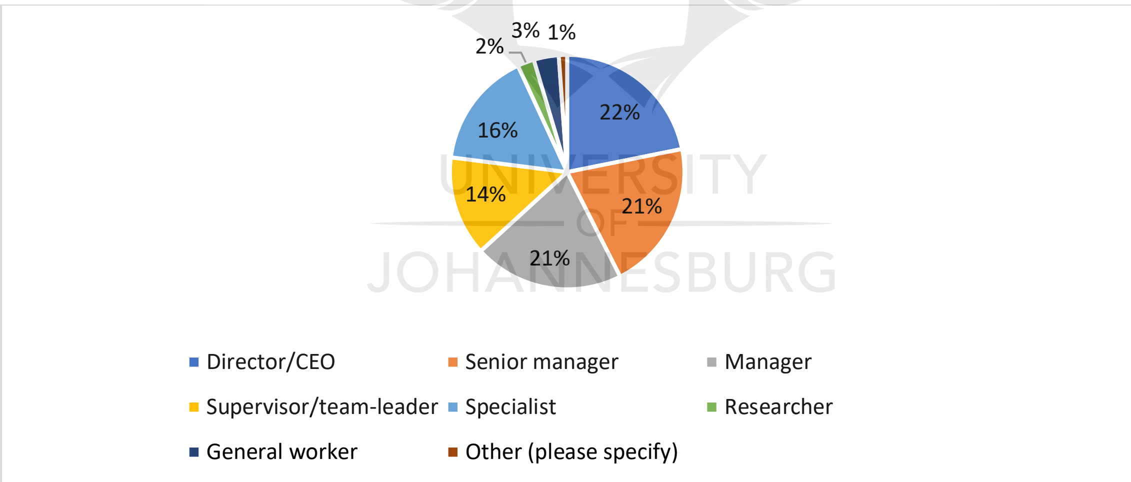

Figure 4.6 Respondents' occupations

The highest positions occupied by the respondents was that of directors/CEO (22%). This was followed by senior managers and managers, which both had 21%, while 16% of the respondents were specialists and this was followed by the category of supervisor and team leaders. The lowest categories were researchers, general workers and 'other' with 2%, 3% and 1% respectively.

4.2.7 Industry experience

Figure 4.7 illustrates the distribution according to the number of years of experience the respondents had in the industry. Most respondents had between five (5) and 10 years experience in their respectful fields. The second highest was between 15 and 20 years with a frequency of 19. The third highest number was 10 to 15 years of experience. The second lowest with 20% were the respondents with over 20 years of experience. The least was 14%,which was the category of respondents with less than five (5) years of experience.

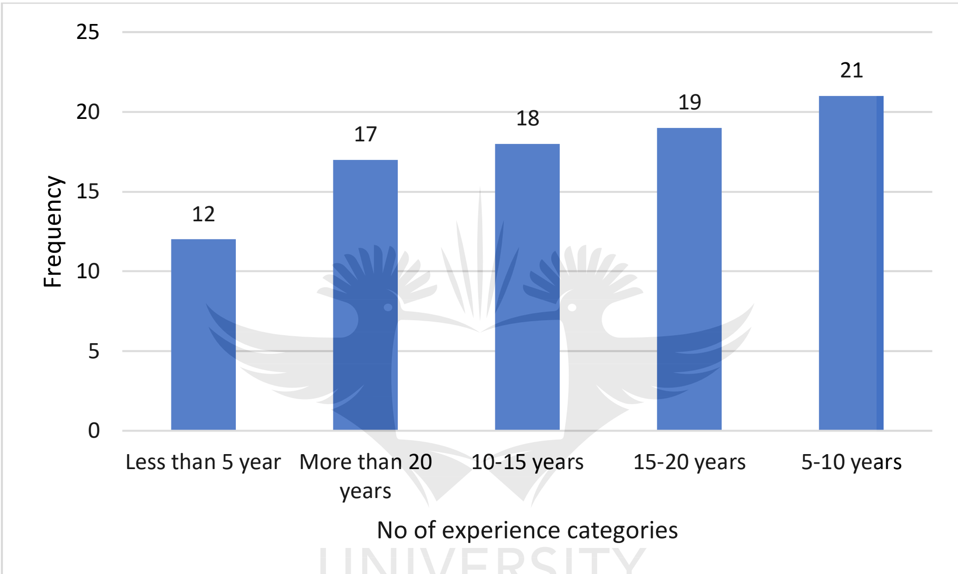

Figure 4.7 Number of years of industry experience

4.2.8 Challenges that SMEs face

The objective of this section was to determine the challenges that SMEs face and the productivity levels of the businesses. The Likert scales used in the questionnaire to provide the extent of the challenges are shown in Table 4.2 below. The weighted mean of the findings is presented in this section of the study. The rankings of the descriptive results are also discussed below.

The Cronbach's Alpha value must be above 0.7 for it to be considered. Values that are above 0.8 are preferable (Pallant, 2007). This process is to confirm the internal reliability and validity scores.

4.2.9 Descriptive analysis for challenges faced by SMEs

The SPSS package was used to measure the dispersion of the values, which was presented using a standard deviation. The standard deviation values that were less than 2, proved that the dispersed values were close to the mean.

A summary of the challenges faced by South African SMEs is presented in Table 4.3. The 5-point Likert scale used to establish the extent of the challenges faced by SMEs was interpreted similarly to the five (5) categories for the data analysis. The category with the highest average percentage is 'Small extent' with 27%, with the highest contributor within the category being 'Labour unrest' with 46%. The second highest category was 'moderate extent' with a total average of 23%. The largest contributor to this average was the challenge of the 'Lack of ICT' with 31%.

Table 4.2 The extent of challenges

Challenges faced by SMEs	**To no extent**	**Small extent**	**Moderate extent**	**Large extent**	**Very large extent**
Crime	28%	39%	23%	9%	1%
Corruption	38%	40%	20%	2%	0%
Labour unrest	36%	46%	13%	3%	2%
High cost of technology	29%	36%	20%	9%	6%
Lack of ICT	7%	23%	31%	18%	21%
Low market accessibility	6%	17%	25%	27%	25%
Lack of finances	5%	9%	24%	29%	33%
Inadequate skills levels and training	12%	16%	30%	23%	19%
Lack of government support	8%	19%	26%	15%	31%
Total average	19%	27%	23%	15%	16%

The third place was the category of 'To no extent', which had a total average of 19%. The greatest contributor was corruption with 38%. The fourth place in the categories was 'Very large extent' with a total average of 16% and this was contributed by 'Lack of finances' with 33%. The lowest category with regards to the total average was to a 'Large extent'. The highest contributor in this category was again the 'Lack of finances (29%).

Table 4.3 Statistics table of challenges

N	Crime	Corruption	Labour unrest	High cost of technology	Lack of ICT	Low market accessibility	Lack of finances	Inadequate skills levels and training	Lack of government support
Weighted Mean	2,48	2,10	2,38	2,71	3,90	4,33	4,48	4,38	3,90
Std. Deviation	0,979	0,809	0,910	1,182	1,217	1,209	1,148	1,264	1,326

Table 4.4 Ranking of Challenges

Challenges faced by SMEs	**Weighted mean**	**Rank**
B1. 7 Lack of finances	4,48	1
B1.8 Inadequate skills levels and training	4,38	2
B1.6 Low market accessibility	4,33	3
B1.5 Lack of ICT	3,90	4
B1.9 Lack of government support	3,90	4
B1.4 High cost of technology	2,71	5
B1.1 Crime	2,48	6
B1.3 Labour unrest	2,38	7
B1.2 Corruption	2,10	8

From the above Table 4.4 the 'Lack of finances' was ranked first with a weighted mean of 4.48. as the highest contributor to the challenges that are faced by SMEs. The challenge that received the second highest weighted mean was 'Inadequate skills and training' with a mean of 4.38. The third highest weighted mean was 'Low market accessibility' with a weighted mean of 4.33. These are the three (3) leading challenges that the respondents strongly agreed that SMEs face.

Table 4.4 also shows the weighted mean that were the least. The third least challenge measured was 'Crime' with a mean of 2.48. The second least challenge with a weighted mean of 2.38 was that of 'Labour unrest'. The least challenge observed with a weighted mean of 2.10 was 'Corruption'.

Table 4.5 KMO and Bartlett's test for B1(Challenges facing SMEs)

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.520
Bartlett's Test of Sphericity	Approx. Chi-Square	52
	df	36
	Sig.	0.038

Table 4.5 shows the KMO sampling adequacy, which being above 0.5, proves that the factor analysis may be of use. The Bartlett's test of sphericity was 0.038, which is less than 0.05 in the significance level test, indicating that the factor analysis may be useful for the data.

Table 4.6 Extent of service and production capability

Productivity	To no extent	Small extent	Moderate extent	Large extent	Very large extent
Produce according to schedule	11%	15%	31%	20%	23%
Customise product	30%	33%	16%	15%	6%
Enough skilled human resources	7%	30%	35%	22%	7%
Receive positive feedback from customers	6%	16%	44%	22%	13%
Monitor production line remotely	41%	30%	19%	10%	0.0%
More than one (1) product per machine can be manufactured	51%	35%	10%	2%	2%

Table 4.6 summarises the extent of the service and production capability levels that the manufacturing SMEs face. The above Table 4.6 can be interpreted in a similar way to that of Table 4.2 with regards to the 5-point Likert scale. The category of ‘To no extent’ had the highest result of 51% and this was ’More than one (1) product per machine can be manufactured’. The lowest in the same category was ‘Receive positive feedback from customers’ (6%). The following category of ‘Small extent’ had the highest ranking with 35% linked to ‘More than one (1) product per machine can be manufactured’. The lowest in the same category was ’Produce according to schedule’ with 15%. The third category of ‘Moderate extent’ was led by ‘Receive positive feedback from customers’ with 44%. The lowest percentage in that category was ‘More than one (1) product per machine can be manufactured’ with 10%. The category of ‘Large extent’ had the highest percentage of 22%, which was contributed to both ‘Enough skilled resources’ and ‘Receive positive feedback from customers’. The lowest percentage was contributed by ‘More than one (1) machine can be manufactured’ with 2%. The last category of ‘Very large extent’ had the highest score of 23%, which was contributed by ‘Produce according to schedule’. The least in the same category with 0% was ‘Monitor production line remotely’.

Table 4.7 Extent of service and production capability statistics

	Produce according to schedule	Customise product	Enough skilled human resources	Receive positive feedback from customers	Monitor our production line remotely	More than one (1) product per machine can be manufactured
Mean	3,86	3,00	3,82	3,82	2,82	2,50
Std. Deviation	1,291	1,217	1,037	1,044	1,011	0,914

Table 4.8 Service and production capability ranking

Description	**Weighted Mean**	**Rank**
B2.1 Produce according to schedule	3,86	1
B2.3 Enough skilled human resources	3,82	2
B2.4 Receive positive feedback from customers	3.82	3

B2.2 Customise product	3,00	4
B2.5 Monitor our production line remotely	2,82	5
B2.6 More than one (1) product per machine can be manufactured	2,50	6

From the above Table 4.8, the productivity measure that received the highest score in terms of the weighted mean was ‘Produce according to schedule’ with a mean of 3.86, hence it is ranked first. The second highest ranking was contributed by ’Enough skilled human resource’ and ‘Receive positive feedback from customers’ were equally ranked as these had the same weighted mean of 3.82. The third least ranked item with a weighted mean of 3.00 was ‘Customise product’. The second least ranked item was ‘Monitor our production line remotely’ with a weighted mean of 2.82. The ranked item was ‘More than one (1) product can be manufactured per machine’ with a weighted mean score of 2.50.

Reliability test

Table 4.9 Reliability statistics for B2 (service and production capability

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha based on standardised items	No of Items
0.525	0.542	5

The above Table 4.9 shows the Cronbach’s Alpha to validate the reliability of the tool that was used. The tool was used on all items and the value that was obtained was 0.542, which shows that the tool was moderately reliable. According to Perry R et al (2004), a Cronbach’s Alpha that is between 0.5 and 0.7 shows moderate reliability (Perry *et al.*, 2004).

4.3 Section C: Industry 4.0 knowledge and perception

4.3.9 Have you heard of the term Industry 4.0?

Table 4.10 Awareness of Industry 4.0

	Frequency	Percentage %
Yes	65	74,7%
No	22	25,3%

Of the 87 surveys returned from the organisations, 22 respondents (25%) had never heard of the term Industry 4.0, whilst 74,7% were aware of the term.

4.3.10 First awareness on the term Industry 4.0

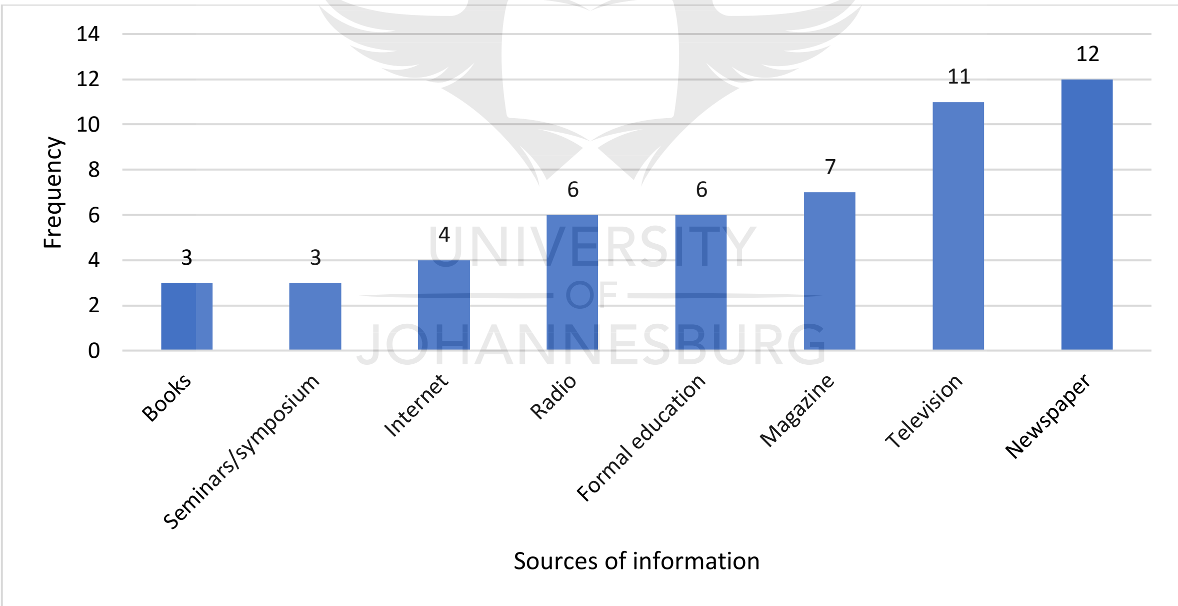

Figure 4.8 First time awareness of the term Industry 4.0

Television and the Internet were the leading sources of information that made people aware of the Industry 4.0 revolution. Formal education and books were amongst the least sources that individuals used to inform themselves of information about the Industry 4.0 phenomenon.

4.3.11 Awareness and knowledge of Industry 4.0

Table 4.11 Extent of Industry 4.0 awareness and knowledge

	Not at all aware	Slightly aware	Somewhat aware	Moderately aware	Very aware
The practicality of Industry 4.0	16%	24%	21%	25%	14%
The relevance of Industry 4.0 on production	14%	26%	23%	23%	14%
The human safety through Industry 4.0	21%	22%	25%	16%	16%
The efficiency of a smart factory	8%	29%	18%	28%	17%
The cost savings through Industry 4.0	10%	29%	20%	22%	19%
The global move towards Industry 4.0	18%	22%	23%	18%	18%

Table 4.11 shows the summary of the description and frequencies of the extent of awareness and knowledge of Industry 4.0. The 5-point Likert scale had the categories (Not at all aware, Slightly aware, Somewhat aware, Moderately aware, Very aware) The group of 'Not at all aware' was the highest with 21%, for the item 'The human safety through Industry 4.0'. The lowest contributor in the same group was 'The efficiency of smart factory' with 8%. The next group of 'Slightly aware' was dominated equally by two items, namely; 'The efficiency of a smart factory' and 'The cost savings through Industry 4.0' both with 29%. The lowest percentage was from 'The human safety through Industry 4.0' with 22%. The third group of 'Somewhat aware' had the highest contribution being" The 'Human safety through Industry 4.0' with 25%. The lowest score in this group was for 'The efficiency of a smart factory' with 18%. The fourth group of 'Moderately aware' was led by 'The efficiency of a smart factory' with 28%. The lowest percentage was from 'The human safety through Industry 4.0' with 16%. The last group of 'Very aware' had the highest with 'The cost savings through Industry 4.0' with 19%. The smallest contributor was from two items, namely; 'The practicality of Industry 4.0' and the 'Relevance of Industry 4.0 on production' with both having a score of 14%.

Table 4.12 Extent of Industry 4.0 awareness and knowledge statistics

	The practicality of Industry 4.0	The relevance of Industry 4.0 on production	The human safety through Industry 4.0	The efficiency of a smart factory	The cost savings through Industry 4.0	The global move towards Industry 4.0
Mean	4,50	4,50	4,55	4,64	4,68	4,55
Std. Deviation	1,307	1,271	1,360	1,250	1,307	1,376

Table 4. 13 Ranking of awareness of Industry 4.0

Description	**Weighted Mean**	**Rank**
C3.5 The cost savings through Industry 4.0	4,68	1
C3.4 The efficiency of a smart factory	4,64	2
C3.3 The human safety through Industry 4.0	4,55	3
C3.6 The global move towards Industry 4.0	4,55	3
C3.1 The practicality of Industry 4.0	4,50	4
C3.2 The relevance of Industry 4.0 on production	4,50	4

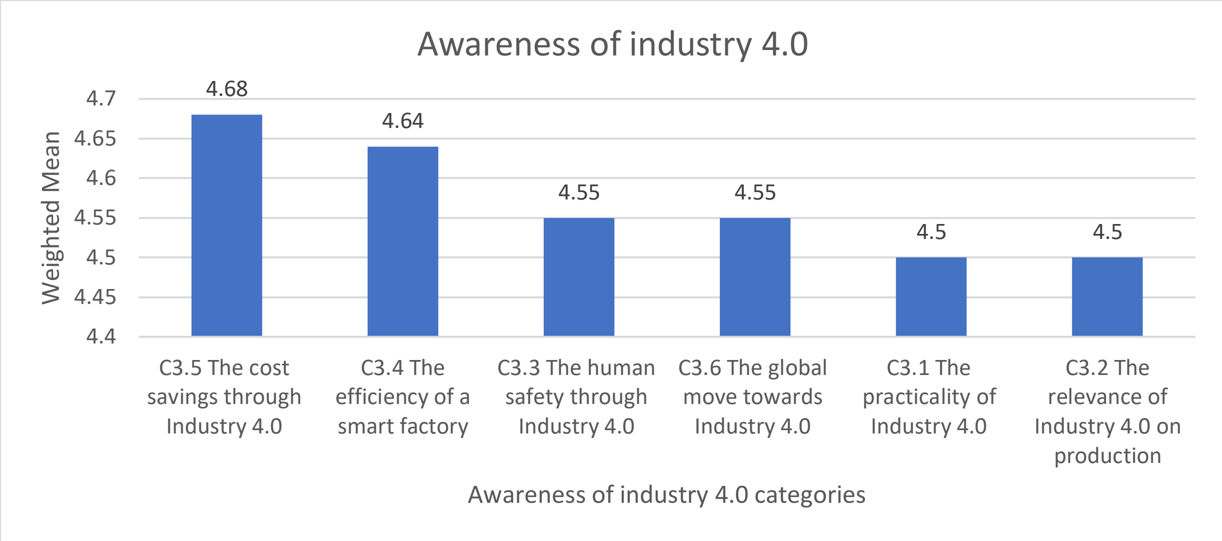

Figure 4.19 Awareness of Industry 4.0

From the above Table 4.13 and Figure 4.10, a ranking system was used for those from the highest ranked to the least. From the observation the highest ranking was 'The cost savings through Industry 4.0' with a weighted mean of 4.68. The next highest ranking was 'The efficiency of a smart factory' with a weighted mean of 4.64. The third ranked with two items, namely 'The human safety through Industry 4.0' and 'The global move towards industry 4.0' was with a mean of 4,55. The least ranked items were 'The practicality of Industry 4.0' and 'The relevance of the Industry 4.0 on production' both with a weighted mean of 4.5.

Reliability test

Table 4.14 Awareness reliability test

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha based on standardised stems	No of Items
0,967	0,967	6

A reliability test tool was used to measure the service and production capability. The Cronbach's Alpha coefficient had a value of 0.967, proving excellent reliability, given that the minimum recommended value is 0.7.

Table 4.15 Extent of the benefits of Industry 4.0

	To no extent	**Small extent**	**Moderate extent**	**Large extent**	**Very large extent**
Smart production	2%	9%	16%	45%	28%
Energy efficiency	0%	7%	14%	38%	41%
Real time performance	2%	3%	27%	32%	36%
Product flexibility	1%	10%	15%	37%	37%
Smart economy (digital economy)	0%	7%	17%	36%	40%

Table 4.15 provides the responses to the extent of the practicality of Industry 4.0, similar to the above 5-point Likert scales (Extent of the benefits of Industry 4.0). The first category of 'To no extent' was dominated by two items, namely 'Smart production' and 'Real time performance' with 2%. The items with the smallest percentages were 'Energy efficiency' and 'Smart economy (digital economy)' with 0%. The category of 'Small extent' had the highest contributor being 'Product flexibility' with 10% whilst the lowest was 'Real time performance' with 3%. The third category of 'Moderate extent' had the highest contributor being 'Real time performance' with 27%, while the least was 'Energy efficiency' with 14%. The fourth category was 'Large extent', which was largely accounted for by 'Smart production' with 45%. The smallest percentage in the same category was 'Real time performance' with 32%. The last category of 'Very large extent' was mainly contributed to by 'Energy efficiency' with 41%. The least percentage in the 'Very large extent' category was 'Smart production' with 28%.

Table 4.16 Extent of the benefits of Industry 4.0 statistics

	Smart production	Energy efficiency	Real time performance	Product flexibility	Smart economy (digital economy)
Mean	4,73	4,95	4,77	4,82	4,59
Std. Deviation	1,002	0,904	0,987	1,023	0,923

Table 4.17 Benefits of Industry 4.0 Ranking

Description	Weighted Mean	Rank
C4.2 Energy efficiency	4,95	1
C4.4 Product flexibility	4,82	2
C4.3 Real time performance	4,77	3
C4.1 Smart production	4,73	4
C4.5 Smart economy (digital economy)	4,59	5

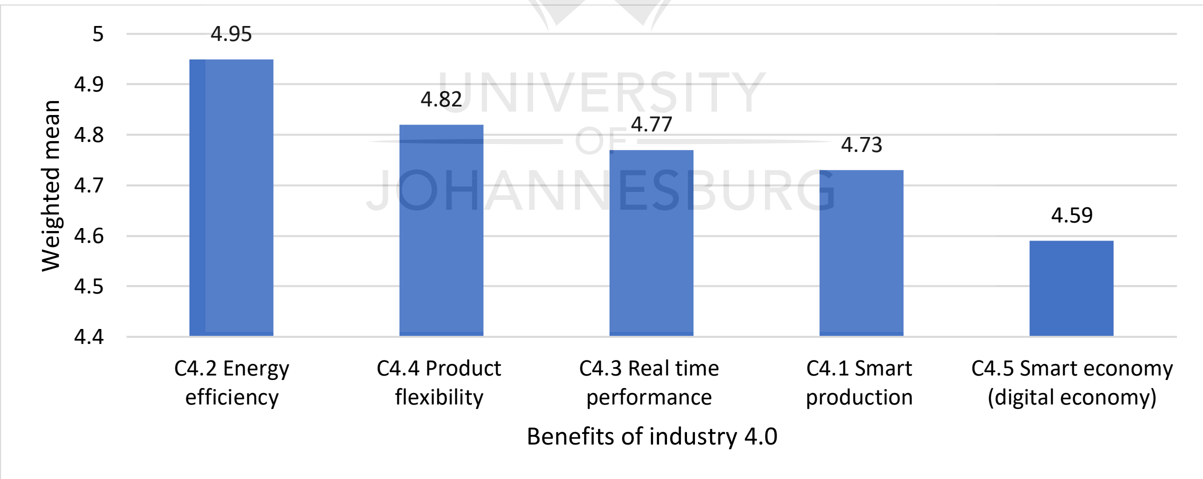

Figure 4.10 Practicality of Industry 4.0

The responses were analysed using the mean scores to rank them according to their positions. The practicality of Industry 4.0 in terms of the items was led by 'Energy efficiency' with a weighted mean score of 4.95. The second highest ranked item was 'Product flexibility' with a weighted mean score of 4.82. The third ranked item was 'Real time performance' with a weighted mean of 4.77. The forth ranked item was

‘Smart production’ with a weighted mean of 4.73. The last and least scored weighted mean was ‘Smart economy (digital economy)’ with a mean score of 4.59.

Table 4.18 Extent of barriers in implementing Industry 4.0

	Not a barrier	**Somewhat of a barrier**	**Moderate barrier**	**Extreme barrier**
Lack of financial resources	1%	3%	22%	74%
The high cost makes it impractical	3%	3%	37%	56%
Scarcity of skilled workers in Industry 4.0	12%	21%	26%	41%
Lack of knowledge on the benefits of Industry 4.0	5%	26%	31%	38%
Businesses focused on daily operation than technology strategies	10%	17%	26%	47%
The economic status of South Africa	3%	17%	28%	52%

Table 4.18 provides the results from the analysis to which extent there are barriers to implementing Industry 4.0. The above Table 4.18 used the 4-point Likert scale, with scales of ‘Not a barrier’, Somewhat of a barrier’, ‘Moderate barrier’, ‘Extreme barrier’ This Likert scale was used to judge the respondents’ opinions with regards to the barriers to implementing Industry 4.0. The first category of ‘Not a barrier’ had the highest score of 12%, which was ‘Scarcity of skilled workers’. The lowest percentage in the same category was ‘Lack of finances’ with 1%. The second category of ‘Somewhat of a barrier’ had the highest score of 26%, which was from ‘Lack of knowledge on the benefits of Industry 4.0’. The lowest score in the same category was ‘Lack of financial resources’ and ‘The high cost makes it impractical’, both having 3%. The third category of the ‘Moderate barrier’ received the highest percentage from ‘The high cost makes it impractical’ with 37%, whilst the lowest percentage was ‘Lack of finances’ with 22%. The last category of this 4-point Likert scale was ‘Extreme barrier’, with the highest score of 74% from ‘Lack of finances’. The lowest received was ‘Lack of knowledge on the benefits of Industry 4.0’ with 38%.

Table 4.19 Extent of barriers in implementing Industry 4.0 statistics

	Lack of financial resources	The high cost makes it impractical	Scarcity of skilled workers in Industry 4.0	Lack of knowledge on the benefits of Industry 4.0	Businesses focused on daily operation than technology strategies	The economic status of South Africa
Mean	3,91	3,82	3,82	3,73	3,95	3,82
Std. Deviation	0,600	0,728	1,045	0,915	1,030	0,872

Table 4.20 Ranking of the barriers in implementing Industry 4.0

Description	**Weighted Mean**	**Rank**
C5.5 Businesses focused on daily operation than technology strategies	3,95	1
C5.1 Lack of financial resources	3,91	2
C5.2 The high cost makes it impractical	3,82	3
C5.3 Scarcity of skilled workers on Industry 4.0	3,82	3
C5.6 The economic status of South Africa	3,82	3
C5.4 Lack of knowledge on the benefits of Industry 4.0	3,73	4

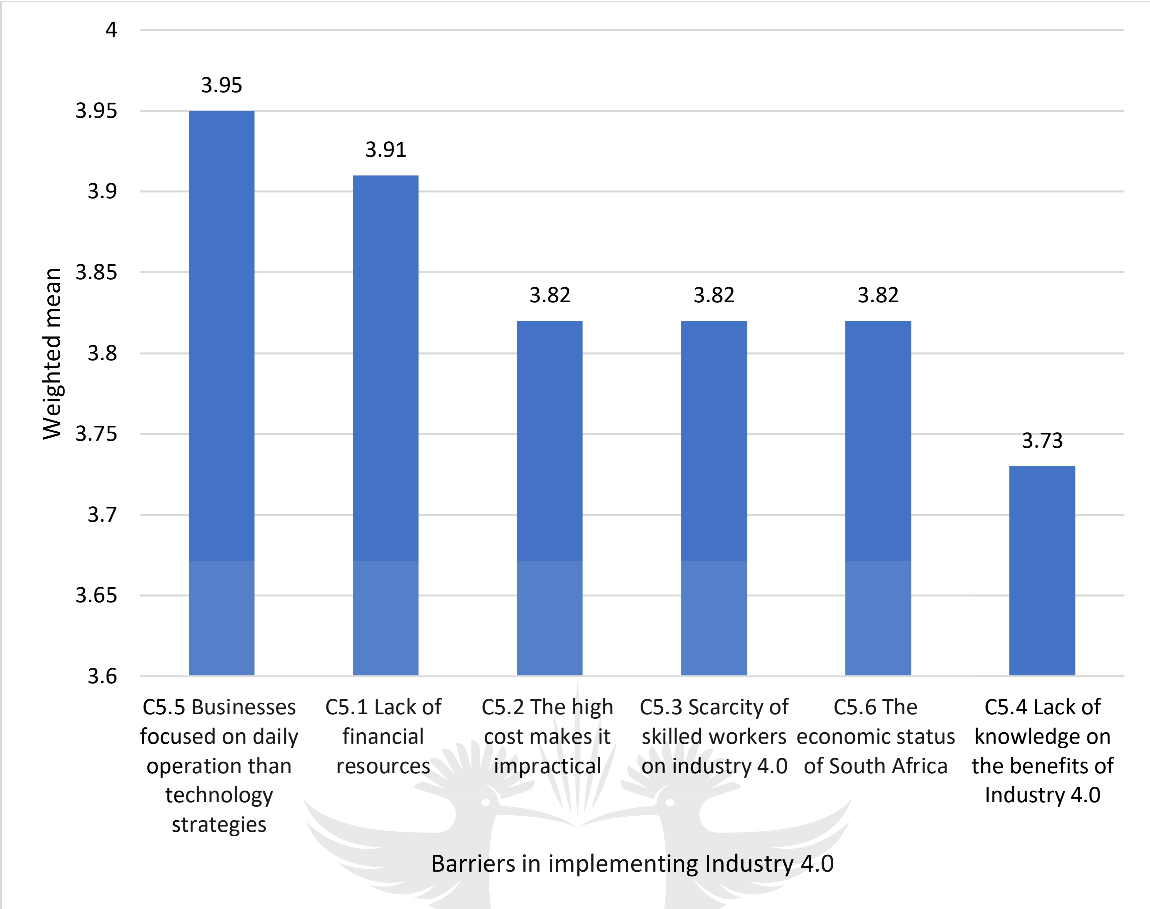

Figure 4.11 Barriers in implementing Industry 4.0

Table 4.20 and Figure 4.12 display the rankings of the barriers of implementing Industry 4.0 in terms of their weighted mean score. The weighted mean score was used to rank the items from the highest to the lowest. The barrier that was ranked first was ‘Business focused on daily operation than technology strategies’ with a mean of 3.95. The second ranked barrier was ‘Lack of financial resources’ with a mean score of 3.91. The third highest barrier was ‘The high cost makes it impractical’, ‘Scarcity of skilled workers on Industry 4.0’ and ‘The economic status of South Africa’ with all three each having a weighted mean score of 3.82. The fourth ranked with the lowest ranking was ‘Lack of knowledge on the benefits of Industry 4.0’ with a weighted mean score of 3.73.

Reliability test

This section of the study had the objective of demonstrating the reliability of the tool that was used. The Cronbach’s Alpha coefficient was used on five (5) of the six (6) variables. As per the recommendation of Perry R. et al, the value of the variable C4.6

was not suitable, hence excluded. The Cronbach's Alpha was 0.725, which is well acceptable as the limit must be above 0.70. This validated that the tool was reliable.

Table 4.21 Reliability test for barriers of implementing Industry 4.0

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha based on standardised items	No. of Items
0,725	0,724	5

Table 4.22 KMO and Bartlett's test for C5

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0,534
Bartlett's Test of Sphericity	Approx. Chi-Square	62,970
	df	15
	Sig.	0,000

Table 4.22 illustrates the KMO measuring of sampling and the Bartlett's test for Sphericity. The KMO was 0.5340 which is weak as the minimum requirement of the recommended KMO is 0.6. However, the Bartlett's test was statistically acceptable as the significant value was 0.000, which is less than the recommended 0.005 and therefore validating the factorability of the correlation matrix.

Table 4.23 Perception about Industry 4.0

Industry 4.0 perceptions	**To no extent**	**Small extent**	**Moderate extent**	**Large extent**	**Very large extent**
Industry 4.0 will destroy SMEs	9%	14%	15%	23%	39%
Industry 4.0 will leave people jobless	3%	6%	13%	36%	42%
South Africa is not ready for industry 4.0	7%	15%	23%	27%	28%

Industry 4.0 will hinder entrepreneurship	9%	17%	21%	23%	30%
Industry 4.0 will enlarge the inequality gap	8%	18%	20%	22%	32%

Table 4.23 summarises the perceptions that the respondents had on the impact Industry 4.0 will have. The 5-point Likert scale was used to categorise the responses into five (5) groups. These included ’To no extent’, which had the highest score of 9.2, contributed by ‘Industry 4.0 will destroy SMEs’, whilst the lowest percentage was due to ‘Industry 4.0 will leave people jobless’ with 3%. The second group of ‘Small extent’ had the highest score of 18% from ‘Industry 4.0 will enlarge the equality gap’. The lowest score in the same category was ‘Industry 4.0 will leave people jobless’ with 6%. The third group which was ‘Moderate extent’ had the highest score being 23%, which was from ‘South Africa is not ready for Industry 4.0’ and the lowest percentage was from ’Industry 4.0 will leave people jobless’ with 13%. The fourth group received the highest score from ‘Industry 4.0 will leave people jobless’ with 36%, whilst the lowest percentage was from ‘Industry 4.0 will enlarge the inequality gap’ with 22%. The last group was the ‘Very large extent’ and this received the highest score of 42% from ‘Industry 4.0 will leave people jobless’ and the lowest percentage was ‘South Africa is not ready for Industry 4.0’ with 28%.

Table 4.24 Perceptions about Industry 4.0 statistics

	Industry 4.0 will destroy SMEs	Industry 4.0 will leave people jobless	South Africa is not ready for industry 4.0	Industry 4.0 will hinder entrepreneurship	Industry 4.0 will enlarge the inequality gap
Mean	4,82	4,68	4,55	4,68	4,59
Std. Deviation	1,358	1,048	1,237	1,328	1,328

Table 4.25 Rankings of perceptions on Industry 4.0

Description	**Weighted Mean**	**Rank**
C6.1 Industry 4.0 will destroy SMEs	4,82	1
C6.2 Industry 4.0 will leave people jobless	4,68	2

C6.4 Industry 4.0 will hinder entrepreneurship	4,68	2
C6.5 Industry 4.0 will enlarge the inequality gap	4,59	3
C6.3 South Africa is not ready for industry 4.0	4,55	4

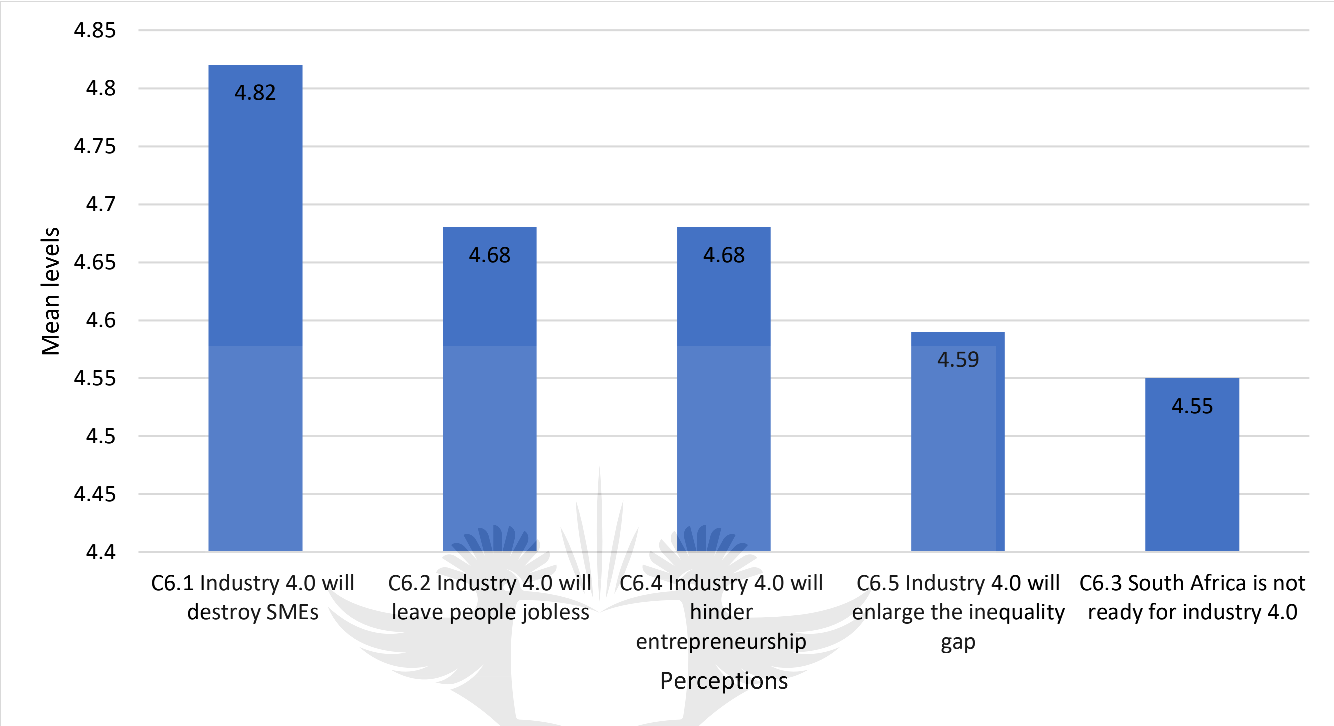

Figure 4.12 Perception of Industry 4.0, mean scores

The perceptions were ranked according to the mean values. The ranking is tabulated in a descending pattern (from highest to lowest mean) as seen in Table 4.25. The perception that had the highest mean was ‘Industry 4.0 will destroy SMEs’ with a weighted mean score of 4.82. The second ranked perception was ‘Industry 4.0 will leave people jobless’ together with ‘Industry 4.0 will hinder entrepreneurship’ with a mean of 4.68. The third ranked perception was ‘Industry 4.0 will enlarge the inequality gap’ with a mean score of 4.59. The least ranked item was ‘South Africa is not ready for Industry 4.0’ with a mean score of 4.55.

Reliability test for C6

Table 4.26 Reliability test for C6

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha based on standardised items	No. of Items
0,630	0,637	5

The Cronbach's Alpha is a measure of the reliability of the Likert scale that was used. The tool considered all the items and obtained a value of 0.630, which shows a moderate reliability.

4.4 Data triangulation

Data triangulation is the process of using different sources as a means to confirm if the results of the research are valid (Zuze & Weideman, 2013). A combination of previous literature, and online questionnaires as primary data collection tools were used for this research study.

4.4.1 Triangulation of complexity factors

The validation from the questionnaires and literature review are the factors that contributed to the results as shown in Table 4.27 below.

Table 4.27 Triangulation

	Contributing factors	Literature	Questionnaire (Weighted mean)
Challenges faced by SMEs in South Africa	Crime	✓	2,48
	Corruption	✓	2,10
	Labour unrest		2,38
	Cost of technology	✓	2,71
	Lack of ICT	✓	3,90
	Market accessibility	✓	4,33
	Lack of finances	✓	4,48

	Inadequate skills levels and training		4,38
	Lack of government support	✓	3,90
Opportunities afforded by Industry 4.0	Energy efficiency	✓	4,73
	Smart economy (digital economy)	✓	4,59
	Product flexibility	✓	4,82
	Real time performance		4,77
	Smart production		4,73
Barriers of implementing Industry 4.0	Lack of financial resources	✓	3,91
	The high cost makes it impractical	✓	3,81
	Scarcity of skilled workers in Industry 4.0		3,82
	Lack of knowledge on the benefits of Industry 4.0		3,73
	Businesses focused on daily operations than technology strategies		3,95
	The economic status of South Africa		3,82

4.5 Conclusion

This chapter completed the analysis of the data that was received from small businesses to determine the challenges that are faced by SMEs and how this affected their service and production capabilities. The chapter also investigated the opportunities that would result in the adoption of Industry 4.0. Through the collected data that was analysed, the awareness and knowledge that the respondents had of Industry 4.0 were presented. The results further revealed the barriers and the perception that the SMEs have of industry 4.0.

CHAPTER 5: DISCUSSIONS AND CONCLUSION

5.1 Introduction

This chapter provides a discussion of the findings from the previous chapter with regards to the data analysis that was performed. The results will be discussed for each section of the questionnaire, and the correlation with the objectives set for the study. The research question will be compared to the data and further take into account the literature in Chapter 2. Additionally, recommendations that are informed by this study and conclusions that were extracted from this study, will be discussed.

5.2 Discussion of results according to the questionnaire sections

Section A: Demographics

a. Years in operation

This first question sought to investigate the number of years that the business had been in operation. Most of the respondents that participated were from companies that had been in operation for 10 to15 years, which meant that the company was well established and had enough business experience. The size and maturity of an organisation, means that the challenges that are recurring are understood and at what scale these affect productivity and profits. This would be vital in understanding their knowledge of the current technology and new technology that can be used to increase business.

b. Number of people employed

The number of people that are employed in an organisation indicated its size and the production levels. This was important as the size contributes greatly to the ability of the organisation to adapt and keep up with the trends. The smaller organisations with nine (9) or less employees are at greater risk as they have limited resources.

c. The sector of the organisations

The focus of the research was on different manufacturing sectors. This was done to get a good representation of the manufacturing industry as they might have different challenges and may further have different opportunities that will be availed by industry. The leading sector that participated was food and beverage with 24% followed by a combination of other sectors that were not listed. The least sector that participated in the survey was that of the plastic and non-metallic industry with 5%.

d. Channel of interaction

The method of interaction was included as an indication if the organisation was already using some technology to interact with their customers or if they were still using traditional methods of physical contact with customers. Forty one percent (41%)of the respondents stated that they were using both virtual and physical interaction. This indicates that there is a level of technology that is already being used in communicating with customers. Only 9% of the manufacturing SMEs stated that they still deal with their customers physically, which meant that if they used technology, it was very limited.

e. Place where major business is conducted

This was asked with an objective to receive a fair representation of the geographical provinces in South Africa with regards to the manufacturing sector. This would be used to compare the awareness and perceptions of those in different provinces in terms of Industry 4.0. Most of the respondents, (33%), highlighted that they did most of their business in Gauteng province. KwaZulu-Natal (KZN) followed with 31%.

f. Occupational level

This category was significant as it indicated the occupational level of the persons employed within the SMEs had. This would further indicate the level of awareness of the challenges and technology trends by the employees. The occupational level of the respondents would highlight the influence they have in the decisions to be taken by the organisation. These decisions will be influenced by the level of awareness and perceptions of the respondents who were directors/CEOs (22%) and 21% were senior managers. This suggests that the opinion of these respondents is of a high regard as they are great influencers in their organisations.

g. Industry experience

The number of years in the industry was aligned with the years in operation of the organisation as it might have been newly formed by industry experts. The number of years of experience speaks to the maturity and knowledge of the respondents in relation to the manufacturing sector. Industry experience is important as it gives organisations an advantage over others and this allows the organisation to use the experience to improve on efficiency. This improvement will be from the industry being able to see and seize opportunities.

5.3 Research questions

This study sought to identify the challenges that are faced by small manufacturing businesses and to identify the opportunities that Industry 4.0 will use to enhance the manufacturing processes. This was achieved by addressing the two research questions:

- **RQ1:** What are the challenges that SMEs are facing?
- **RQ2:** What opportunities does Industry 4.0 provide for the manufacturing processes of SMEs?

Section B: Challenges that are faced by SMEs

The objective of this section was to establish the challenges and the extent to which the organisations experience these. There were nine (9) challenges that were selected by the researcher that were influenced by previous literature. To quantify the extent of these challenges, a 5-pointLinkert scale was used to allow the participants to score the seriousness of these challenges.

a. Extent of challenges faced by the manufacturing SMEs

The greatest challenge proved to be ‘Lack of finances’. Over 25% of the participants deemed the ‘Lack of finance” as a challenge to a ‘Very large extent’. The directors of the organisations further stated that the ‘Lack of finances’ was a hindrance to their growth as it does not allow them to seize opportunities. The ‘Lack of finance’ also meant that the resources were limited, including skilled human resources that could add value and grow the SMEs. As most SMEs do not have a long track record, investors are hesitant to invest in them, hence the improvement of technology if not critical in the processes are not prioritised. The directors/CEOs of most SMEs are the main shareholders, which meant that even the capital invested from them, and the resources, may be limited. The challenge that had the highest score was ‘Inadequate skills and training', this may have been due to the number of uneducated people in South Africa. The socioeconomic status of South Africa limits the number of people, who can be educated, due to financial constraints. The third challenge that was 'Highly ranked' was 'Low market accessibility', which obstructs SMEs from exploiting other markets such as international markets. The lack of finances limits SMEs from shipping internationally as some do not have the knowledge of international trade and regulations. Furthermore, they do not have the resources, which can be dedicated to understanding and assisting how to tap into those markets. The low level of digitisation and documentation in the SME process forces them to only trade with clients that are local. The 'Lack of government support' was ranked as the fourth challenge. The government has funding houses but the lengthy processes and requirements hinder SMEs from utilising the capital that has been provided. Furthermore, the regulations and trade restrictions that are set by government often have big businesses in mind but also apply to SMEs. This becomes a major challenge when the small businesses are failing to comply.

The two least ranked challenges were 'Labour unrest' and 'Corruption'. The respondents stated that 'Labour unrest' was at a minimal level as even the number of overall staff was not extremely large hence could be managed better. Corruption seemed to not affect the SMEs to a great extent. This may be that there is greater transparency in small organisations.

b. Service and production capabilities

Most of the participants stated that they were able to produce according to a schedule and hence, receive positive feedback from clients. The challenge was in the equipment that the SMEs were using and 'One (1) machine can only produce one (1) product'. This suggests that if there was no demand for a certain product, the machine cannot be used. Lastly, many of the SMEs were not able to remotely manage the organisation. The inability to monitor and track the production line meant that there needs someone on site to monitor and receive instructions. Another limitation was that most of the machines that the businesses have were not able to customise products to customer needs and this can be a factor that obstructs the growth of the business.

Section C: Industry 4.0 knowledge and perception

This section was to determine the awareness and level of knowledge that the respondents had with regards to Industry 4.0. This information would determine if participating SMEs were aware of the technology revolution of Industry 4.0 and if they saw opportunities to improve their processes. This section would further investigate the barriers that may possibly hinder the adoption of Industry 4.0. In this section, the researcher sought to understand the perceptions that the participants had on Industry 4.0, as this would directly determine the adoption or the lack of adoption of Industry 4.0.

c. Awareness of the term Industry 4.0

This question sought to understand if the respondents were aware of the term 'Industry 4.0'. The awareness of the term was an indication if the respondent had to be first educated about the term and what it entails. Of the respondents, 75% were aware of the term.

d. Initial source of knowledge on Industry 4.0

The level of knowledge and insight was determined by the source when the respondent first heard of the term. Other sources have limited information whilst others had much more. The leading source of information of Industry 4.0 was gained from television (20%), which may mean that the respondents have a high level of knowledge about the term.

e. Extent of Industry 4.0 awareness

There were five (5) statements that were used to investigate the level of knowledge on Industry 4.0. To allow the reader to make a fair judgement, a 5-point Linkert scale was used. This would be to have the respondents score their understanding and the details around the term. This question included some of the benefits of using Industry 4.0 and the relevant perception of the technology. Many respondents acknowledged that there would be greater efficiency with smart factories. Furthermore, there was a perception that there will be cost savings through the adoption of this technology. Human safety within Industry 4.0 was not recognised, which may have been due to the respondents having insufficient information.

f. **Benefits of Industry 4.0 in the organisation**

From the descriptive analysis , 'Energy efficiency' was ranked as the most recognised benefit of Industry 4.0. An increase in energy efficiency has the potential to lower electricity bills, allowing the funds to be channelled to other sectors in the business. Furthermore, the energy efficiency means lower greenhouse gas emissions, which can be used to support sustainable development and be used as a marketing strategy. Smart economy is another benefit the SMEs deemed important. Smart economy improves connectivity, which can result in access to foreign markets.

g. **Barriers to implementing industry 4.0**

The barrier that was ranked as the one with the highest mean was 'Businesses focused on the daily operation than technology strategy'. This was due to many reasons, which include 'Lack of financial resources', which was the second ranked barrier. The lack of finances results in the human resources being used in daily operations and meeting production demands that are always present. The equipment that is required to adopt Industry 4.0 comes at a high cost and most of the SMEs do not have the finances to invest in the technology though it may be beneficial to them. There are skills that are necessary for the implementation of Industry 4.0 and this can be done by individuals, who are knowledgeable about the subject. Most of the SMEs cannot afford to employ these skills due to their small profit levels and the economic state of South Africa. The economic state of the country has not allowed for many experts on the subject of Industry 4.0 to a degree that where even small businesses can have access to these experts. Lastly, many decision-makers have not known the benefits of Industry 4.0 being focused on the production and daily operations. The six (6) factors that are the barriers of implementing industry 4.0 can be merged and simplified into three (3) factors, which are as below:

Factor 1 = Scarcity of skilled workers in Industry 4.0 (C5.3) + Businesses focused on the daily operation than technology strategy (C5.5)

Factor 2 = Lack of financial resources (C5.1) + The high cost makes it impractical (C5.2)

Factor 3 = The economic status of South Africa (C5.6) + Lack of knowledge on the benefits of Industry 4.0 (C5.4)

Factor 1: Operational barriers
This factor proved that SMEs are not ready to implement Industry 4.0 in their organisations. The operational barrier was based on the lack of the skills that Industry 4.0 requires. Moreover, the SMEs did not have any strategy in place that is related to the changing technology.

Factor 2: Financial barriers
The financial barrier was a factor that hinders the organisations from growing. There are multiple influencers to this challenge, one being the financial institutions are not very keen in investing in small businesses as they are seen as high risk.

Factor 3: National status barriers
The instability of the economic and political landscape has become a barrier in the implementation of Industry 4.0. This is a challenge as international investors are not confident in the stability of South Africa.

h. Industry 4.0 perceptions

Many of the respondents had a perception that the implementation of Industry 4.0 will leave people jobless. This perception is a negative one, which may delay the adoption of the technology as the SMEs may want to keep their employees. The perception that Industry 4.0 will destroy SMEs was ranked second. This perception is driven by the assumption that big businesses, which adopt Industry 4.0 will become more efficient and lower the prices of their products. This will make SMEs unable to compete.

5.4 Conclusion according to research objectives

The study had set two objectives that were to address the research questions. The study had an objective of identifying the challenges that are faced by manufacturing SMEs and sought to identify the opportunities that Industry 4.0 would provide for these small businesses to improve their manufacturing processes.

RQ1: Identify and quantify the challenges faced by manufacturing SMEs

For the study to achieve the objectives, the study conducted a broad literature review to be able to extract the challenges that are faced by SMEs, and to what extent these SMEs are facing these challenges. Upon the analysis of the results from the collected data, it was proven that the challenges that were highlighted by some of the literature does affect the SMEs. The triangulation in Table 4.27 revealed that there was a convergence with the regards to the challenges that were identified as contributors. To measure and validate the extent to which challenges were faced by SMEs, the respondents were asked to determine the extent of these. The results that were summarised in Table 4.4 proved that the lack of finances was a leading challenge for SMEs. This was similar to the findings in the literature, however, there was a divergence of the second leading challenge, which did not recognise 'Inadequate skills levels and training as a challenge'. The data that was collected proved otherwise, this was deemed by the respondents as a challenge. Over 20% of the respondents determined this was a challenge to a 'Large extent'. The challenge of market accessibility was proven by the collected data that has not changed as there were still limitations for SMEs to have greater access to other markets. The comparison between the researched literature and collected data demonstrated a union between the identified challenges. There was a discrepancy in the challenge of 'Labour unrest' and 'Inadequate skills and training'.

RQ2: Identify the opportunities availed by Industry 4.0 for manufacturing processes.

A further in-depth study of the opportunities that Industry 4.0 has for manufacturing SMEs should be investigated. The opportunities that were seen for Industry 4.0 will be used to address some of the highlighted challenges faced by SMEs. The literature revealed that a smart product was a benefit to Industry 4.0. The smarter the products, the more flexible the products become. The triangulation in Table 4.27 revealed that both the literature and the collected data viewed some of the opportunities. Energy efficiency was a dominant advantage that the respondents highlighted. This would partly address the challenge of lack of finance as there would be cost savings that can be channelled elsewhere. The benefit of the smart economy and product flexibility will address the challenge of market accessibility. This was an advantage that the literature had also emphasised. There was however, a divergence as some of the literature had not discussed real time performance as an advantage that would be exploited by the SMEs. The respondents regarded this advantage as one that can mitigate the lack of finance. The real time performance will improve the monitoring of the processes and enable the businesses to make informed decisions. Further opportunities that Industry 4.0 would bring, according to the observations of the researcher, was improved collaborative workings in companies and businesses. The observation further highlighted that profit and compliance will be made easier as most processes will be done in a more efficient manner.

5.5 Recommendations

The recommendations section is extracted from the findings of the results and the literature. In an attempt to quantify the extent of the challenges faced by manufacturing SMEs, the respondents were asked to score the effect that the challenges have on their organisations. Though the scales were able to provide insight into the challenges, the scales did not make it possible to further investigate other challenges and give a detailed response.

The research was dependent on the participants' ability to understand the questions and give a fair and true response. The feedback from the respondents indicated that some of them were not too knowledgeable of Industry 4.0. Some of their perceptions may change as they are exposed to Industry 4.0 in more detail. The study focused only on registered small businesses whilst the challenges faced by informal SMEs may differ.

The research only investigated three (3) provinces. This means that the results do not represent the SME sector in South Africa.

The adoption of Industry 4.0 would have a positive impact in many of the South African SMEs. This would allow them to compete globally, thereby attracting more customers. The more efficient systems become, the more flexible prices can be.

Recommendation for future research

Future research must include a larger number of SMEs as it was found in the literature that there are at least 667 433 formal SMEs in South Africa. This meant that the sample of the study was very small. Although the study was able to extract insight, it is recommended that a larger sample be taken.

The scope of a future study should include other stakeholders to compare and make a more accurate finding. These stakeholders may include big business, service providers and government. The inclusion of these stakeholders would provide a comparative study to have a better framework to resolve these challenges.

5.6 General Conclusion

This study set an objective to investigate the challenges, and the extent of these on small manufacturing businesses, and subsequently determine the opportunities that Industry 4.0 would have on the manufacturing processes. The challenges and opportunities were first identified through the exploration of the literature. This influenced the design of the tool that was used as the research instrument.

The Likert scale was used to determine the extent of the challenges, awareness of Industry 4.0, the barriers in implementing Industry 4.0. and finally, the perceptions that the participants had of Industry 4.0. The two major challenges that were revealed was the lack of finance and low market accessibility. This is because of lack of government support, investors being hesitant to invest and the low ICT infrastructure. The opportunities that Industry 4.0 will bring to the manufacturing sector that were ranked high was energy efficiency and smart economy. The energy efficiency will allow the SMEs to save costs on energy whilst the smart economy will enable these small businesses to operate in a larger market.

The lack of finance and the high costs were the major challenges. Financial issues were the main barriers to the implementation and adoption of Industry 4.0. The research discovered that many participants had a perception that Industry 4.0 was going to leave many people jobless and that the adoption of this technology will destroy SMEs. This negative perception of industry may delay the adoption and implementation of Industry 4.0.

Finally, SMEs must be supported in the best manner for them to continue creating employment. The improvement of technology will afford SMEs an opportunity to grow and thrive. The available technology should be used to mitigate some of the challenges that are faced by these small businesses.

REFERENCES

Abor, J. (2010). Issues in SME Development in Ghana and South Africa. *International Research Journal of Finance and Economics*, (39), pp. 218–228. Available at: https://www.researchgate.net/publication/285704505.

Ahmed Fouad, M.A. (2013). Factors affecting the performance of small-medium enterprises (SMES) in the manufacturing sector of Cairo, Egypt. *International Journal of Business and Management Studies*, 5(2), pp. 157–166.

Alcácer, V. & Cruz-Machado, V. (2019). Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems. *Engineering Science and Technology, an International Journal*, 22(3), pp. 899–919. doi: 10.1016/j.jestch.2019.01.006

Alexandre, M. (2014). *Framework, Challenges and Perspectives.* Master of Engineering Thesis. Hochschule RheinMain: University of Applied Science, Rüsselsheim.

Ali Chaudhry, I., Ali Khan, A. & Shami, M. (2004). Manufacturing Applications of Artificial Intelligence. *Journal of Engineering and Applied Science*, 23(2), pp. 28–33. Available at: https://www.researchgate.net/publication/221680342.

Ang, J.H., Goh. C, Saldivar. A & Li. Y. (2017). Energy-efficient through-life smart design, manufacturing and operation of ships in an industry 4.0 environment. *Energies,* 10(5), pp. 1–13. doi: 10.3390/en10050610

Arvind, A. & Bourne, D. (2016). Architecture for Industry 4. 0 based Manufacturing Systems, Carnegie Mellon University Pittsburgh, PA.

Bahrin, M.A.K., Othman. M. F, Azli. H. N & Talib. F. (2016). Industry 4.0: A review on industrial automation and robotic. *Jurnal Teknologi*, 78(6–13), pp. 137–143. doi: 10.11113/jt.v78.9285

Baker, T. & Nelson, R.E. (2005). Creating something from nothing: Resource construction through entrepreneurial bricolage. *Administrative Science Quarterly*, 50(3), pp. 329–366. doi: 10.2189/asqu.2005.50.3.329

Bureau for Economic Research (2016). The Small Medium Micro Enterprise sector of South Africa: Commissioned by The Small Enterprise Development Agency - Executive summary. *Bureau for Economic Research*, (1), p. 34. doi: 10.1145/2647908.2655974

Y. S. P. Chiu, Y. R. Chen, V. Chiu, and S. W. Chiu. (2019). Joint effects of stochastic machine failure, backorder of permissible shortage, rework, and scrap on stock replenishing decision. *International Journal of Industrial Engineering Computations*, 10(2), pp. 263–280. doi: 10.5267/j.ijiec.2018.6.005

Church, G. (2015). Science can't solve it. Nature international weekly journal of science, Vol 522(7557) *Macmillan Publishers Limited*.

M. Gidlund, S. Han, U. Jennehag, E. Sisinni, and A. Saifullah. (2018). Industrial Internet of Things: Challenges, Opportunities, and Directions. *IEEE Transactions on Industrial Informatics. IEEE,* 14(11), pp. 4724–4734. doi: 10.1109/tii.2018.2852491

Gono S.H.G. (2014). The adoption and impact of ICT in South African SMEs, Strategic Change 25:717-734. DOI:10.1002/jsc.2103. pp. 1–39.

Green, A. (2003). Credit Guarantee Schemes for Small Enterprises: An Effective Instrument to Promote Private Sector-Led Growth? *Unido, (8).* Available at: https://books.google.co.za/books?id=gHNcnQEACAAJ&dq=barberis+and+thaler&hl=en&sa=X&ved=0ahUKEwjU9-CVy_rYAhUCOhQKHRLyC9wQ6AEIKDAA.

Group, E. (2013). Growing the global economy through SMEs Contents. Growing the Global Economy through SME's, 1(1), pp. 1–44.

Harrison, R., Vera, D. & Ahmad, B. (2016). Engineering the smart factory. *Chinese Journal of Mechanical Engineering,* 29(6), pp. 1046–1051. doi: 10.3901/CJME.2016.0908.109

Hercko, J., Slamkova, E. & Hnat, J. (2015). Industry 4.0 as a factor of productivity increase, (March), pp. 1–5. doi: 10.1007/s00426-005-0020-8

Hoegl, M., Gibbert, M. & Mazursky, D. (2008). Financial constraints in innovation projects: When is less more?, *Research Policy*, 37(8), pp. 1382–1391. doi: 10.1016/j.respol.2008.04.018

Howell, R., Van Beers, C. & Doorn, N. (2018). Value capture and value creation: The role of information technology in business models for frugal innovations in Africa. *Technological Forecasting and Social Change. Elsevier*, 131(December 2016), pp. 227–239. doi: 10.1016/j.techfore.2017.09.030

Ibarra, D., Ganzarain, J. & Igartua, J.I. (2018). Business model innovation through Industry 4.0: A review. *Procedia Manufacturing. Elsevier B.V*., 22, pp. 4–10. doi: 10.1016/j.promfg.2018.03.002

Johnston, S.F. (2018). The technological fix as social cure-all: Origins and implications. *IEEE Technology and Society Magazine*, 37(1), pp. 47–54. doi: 10.1109/MTS.2018.2795118

Joshi, A. S. Kale, S. Chandel, and D. Pal. (2015). Likert Scale: Explored and Explained. *British Journal of Applied Science & Technology*, 7(4), pp. 396–403. doi: 10.9734/bjast/2015/14975

Pallant, J.F. (2007) .SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS for Windows Version 15.

Jull, J. (1999). The second industrial revolution. The history of a concept. *Rivista internazionale di storia della storiografia,* (36), pp. 81–90. doi: 10.1016/B978-0-12-801996-2/00008-8

Kergroach, S. (2017). Industry 4.0: New Challenges and Opportunities for the Labour Market. *Foresight and STI Governance*, 11(4), pp. 6–8. doi: 10.17323/2500-2597.2017.4.6.8

Kim, J. (2018). Are countries ready for the new meso revolution? Testing the waters for new industrial change in Korea. *Technological Forecasting and Social Change. Elsevier,* 132 (September 2017), pp. 34–39. doi: 10.1016/j.techfore.2017.11.006

Kunene, T.R. (2008). *A critical analysis of entrepreneurial and business skills in SMEs in the textile and clothing industry in Johannesburg, South Africa*. PhD in Entrepreneurship, Management Sciences, South Africa, University of Pretoria

Kusiak, A. (2019). Fundamentals of smart manufacturing: A multi-thread perspective. *Annual Reviews in Control*, pp. 1–7. doi: 10.1016/j.arcontrol.2019.02.001

Leboea, S.T. (2017). *The Factors Influencing SME Failure in South Africa.* Graduate School of Business, University of Cape Town, p. 136.

Lee, K. D. Go, I. Park, and B. Yoon. (2017). Exploring Suitable Technology for small and medium-sized enterprises (SMEs) based on a Hidden Markov Model using patent information and value chain analysis. *Sustainability* (Switzerland), 9(7). doi: 10.3390/su9071100

Lekidis, A. & Katsaros, P. (2018). Model-based design of energy-efficient applications for IoT systems. *Electronic Proceedings in Theoretical Computer Science, EPTCS*, 272(MeTRiD), pp. 24–38. doi: 10.4204/EPTCS.272.3

Liao, Y. F. Deschamps, E. de F. R. Loures, and L. F. P. Ramos. (2017). Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. *International Journal of Production Research.* 55(12), pp. 3609–3629. doi: 10.1080/00207543.2017.1308576

Loic Tassel (2019). *Why strive for Industry 4.0?*, World Economic Forum reports. Available at: https://www.weforum.org/agenda/2019/01/why-companies-should-strive-for-industry-4-0/ (Accessed: 2 October 2019).

Lorimer, J.W. (1983). Phenomenological Coefficients and Frames of Reference for Transport Processes in Liquids and Membranes .3. Theory of Convective Contributions to Isothermal and Non-Isothermal Transport in Ionic Membranes. *Journal of Membrane Science*, 14(3), pp. 275–302. doi: 10.1109/MIE.2014.2312079

Lu, Y. (2017). Journal of Industrial Information Integration Industry 4 . 0 : A survey on technologies , applications and open research issues. *Journal of Industrial Information Integration*, 6, pp. 1–10. doi: 10.1016/j.jii.2017.04.005

Luthra, S. & Mangla, S.K. (2018). Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies. *Process Safety and Environmental Protection. Institution of Chemical Engineers*, 117, pp. 168–179. doi: 10.1016/j.psep.2018.04.018

Mananzai, M. & Fatoki, O. (2012). Access to Finance in the SME Sector: A South African Perspective. *Asian Journal of Business Management*, 4(1), pp. 58–67.

Marie, D. (2018) *The Hidden Costs of Computer-aided Design (*CAD). CR4 Engineering community.

Mauch, J.E. & Park, N. (n. d.) *Guide to the Successful Thesis and Dissertation* A Handbook for Students and Faculty, New York dekker publication, Fifth Edition.

Mittal, S. M. A. Khan, D. Romero, and T. Wuest. (2018). A critical review of smart manufacturing & Industry 4.0 maturity models: Implications for small and medium-sized enterprises (SMEs). *Journal of Manufacturing Systems.* 49, pp. 194–214. doi: S0278612518301341

Moester, D. (2017). Securing the future for the Manufacturing Industry : Towards the adoption of the Smart Industry, University of Twente, pp. 1–58.

Moktadir, M.A. S. M. Ali, S. Kusi-Sarpong, and M. A. A. Shaikh. (2018). Assessing challenges for implementing Industry 4.0: Implications for process safety and environmental protection. *Process Safety and Environmental Protection. Institution of Chemical Engineers*, 117, pp. 730–741. doi: 10.1016/j.psep.2018.04.020

Monitor, D.T. (2017). Energy harvesting to power the rise of the Internet of Things.European commission journal. https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Energy%20harvesting%20v1_0.pdf

Moraes, E.C. & Lepikson, H.A. (2017). *Industry 4.0 and its impacts on society*. Proceedings of the International Conference on Industrial Engineering and Operations Management, pp. 729–735.

Müller, J.M., Buliga, O. & Voigt, K. (2018). Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change,* 132, pp. 2–17. doi: 10.1016/j.techfore.2017.12.019

Nilsen, S. & Nyberg, E. (2016). The adoption of Industry 4.0- technologies in manufacturing – a multiple case study, *KTH Industrial Engineering and Management*.

Nowak, J, Odden. J, Myslajek. R, Ozolins, J. (2012). Research Data. *Acta agriculturae slovenica*, pp. 199–201. doi: 10.1016/B978-0-443-06589-7.50019-5

Nuvolari, A. (2018). Understanding successive industrial revolutions: A “development block” approach. *Environmental Innovation and Societal Transitions,* pp. 1–12. doi: 10.1016/j.eist.2018.11.002

Oesterreich, T.D. & Teuteberg, F. (2016). Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry. *Computers in Industry,* 83, pp. 121–139. doi: 10.1016/j.compind.2016.09.006

Office of the President (2004). National Small Business Act, 1996. No 102 of 1996: National Small Business Act, 1996., 8(1901), pp. 1–16.

Olawale, F. & Garwe, D. (2010). Obstacles to the growth of new SMEs in South Africa: A principal component analysis approach. *African Journal of Business Management,* 4(5), pp. 729–738. doi: 10.1177/2050640613502897

Paridah, M & Kanama. D. (2016). Manufacturing Transformation toward Mass Customization and Personalization in the Traditional Food Industry. *Intech, i(tourism),* p. 13. doi: http://dx.doi.org/10.5772/57353

Pereira, A.C. & Romero, F. (2017). A review of the meanings and the implications of the Industry 4.0 concept. *Procedia Manufacturing,* 13, pp. 1206–1214. doi: 10.1016/j.promfg.2017.09.032

Nikoloski, K. (2014). The Role of Information Technology in the Business Sector. *International Journal of Science and Research* (IJSR), 3(12), pp. 303–309. Available at: https://www.ijsr.net/archive/v3i12/U1VCMTQzMjA=.pdf.

Du Plessis, H. (2012). *A roadmap for smart city services to address small business challenges.* University of Johannesburg. Available at: https://ujcontent.uj.ac.za/vital/access/manager/Index?site_name=Research Output.

Du Plessis, J.C. (2017). A framework for implementing Industry 4 . 0 in learning factories. Stellenbosch university.

Pradhan, A. & Agwa-Ejon, J. (2018). *Opportunities and challenges of embracing smart factory in South Africa*. Portland International Conference on Management of Engineering and Technology: Managing Technological Entrepreneurship: The Engine for Economic Growth, Proceedings. doi: 10.23919/PICMET.2018.8481968

Qeshmy, D.E, Da Silva. E, Makdisi. J. (2019). Managing Human Errors: Augmented Reality systems as a tool in the quality journey. *Procedia Manufacturing*, 28, pp. 24–30. doi: 10.1016/j.promfg.2018.12.005

Qin, J., Liu, Y. & Grosvenor, R. (2016). A Categorical Framework of Manufacturing for Industry 4.0 and beyond. *Procedia CIRP,* 52, pp. 173–178. doi: 10.1016/j.procir.2016.08.005.

Davies, R. (2015). Briefing Industry 4.0 Digitalisation for productivity and growth. *European Parliamentary Research Service.* Available at: http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf.

Rajput, S. & Singh, S.P. (2019). Connecting circular economy and industry 4.0. *International Journal of Information Management*, pp. 98–113. doi: 10.1016/j.ijinfomgt.2019.03.002

Ray, P.K. & Ray, S. (2010). Resource-constrained innovation for emerging economies: The case of the Indian telecommunications industry. *IEEE Transactions on Engineering Management,* 57(1), pp. 144–156. doi: 10.1109/TEM.2009.2033044

Roblek, V., Meško, M. & Krapež, A. (2016). *A Complex View of Industry 4.0.* SAGE Open, 6(2). doi: 10.1177/2158244016653987

Rooney, J.J., Heuvel, L.N. & Lorenzo, D. (2002). Reduce Human Error. *Quality Progress*, 35(9), pp. 27–36. Available at: file:///C:/Users/Barbara/Downloads/reducing human error QP.pdf.

Santos, C, Mehrsai. A, Barros. A, Araujo. M, Ares. E, (2017). Towards Industry 4.0 : an overview of European strategic roadmaps. *Procedia Manufacturing*, 13, pp. 972–979. doi: 10.1016/j.promfg.2017.09.093

Santos, K, Loures.E Piechnicki. F, Canciglieri. O,. (2017). Opportunities Assessment of Product Development Process in Industry 4.0. *Procedia Manufacturing*, pp. 1358–1365. doi: 10.1016/j.promfg.2017.07.265

Serei, T. (2016). *The perceived effectiveness of the role of government in SME development* Tshediso Serei: A research proposal submitted to the Gordon Institute of Business Science, University of Pretoria, in partial fulfilment of the requirements for the degree of Master of business administration, University of Pretoria.

Shah, S.B.H, Qarabash.H, Qarabash. N. (2018). Smart grid communication and information technologies in the perspective of Industry 4.0: Opportunities and challenges. *Computer Science Review,* 30, pp. 1–30. doi: 10.1016/j.cosrev.2018.08.001

Shanmugam, J.K. & Ali, A. (2012). An Exploratory Study of IC and FP SME, *International Journal of Business Research and Management*, 3(2), pp. 90–99.

Shwab, K. (2016). *The fourth industrial revolution.* World Economic Forum. Available at: https://luminariaz.files.wordpress.com/2017/11/the-fourth-industrial-revolution-2016-21.pdf.

Singh, R. (2006). *Introduction to Basic Manufacturing Processes and Workshop Technology*. Published by New Age International (P) Ltd., Publishers.

Singh, T., Chetty, N. & Karodia, A.M. (2016). An Investigation into the Impact of Absenteeism on the Organisational Performance of a Private Security Company in Durban , KwaZulu-Natal. *Singaporean Journal of Business Economics and Management Studies,* 4(11), pp. 105–159. doi: 10.12816/0027227

Sommer, L. (2015). Industrial revolution - Industry 4.0: Are German manufacturing SMEs the first victims of this revolution? *Journal of Industrial Engineering and Management,* 8(5), pp. 1512–1532. doi: 10.3926/jiem.1470

Statistics South Africa (StatsSA) (2014). Statistical release Quarterly Labour Force Survey: Quarter 3, 2014. *Quarterly Labour Force Survey*, PO211(February), pp. 1–70. Available at: http://beta2.statssa.gov.za/publications/P0211/P02113rdQuarter2014.pdf.

Timm, S. (2015). The Causes of the Failure of New Small and Medium Enterprises in South Africa. *Mediterranean Journal of Social Sciences*, pp. 1–16. doi: 10.5901/mjss.2014.v5n20p922

Sung, T.K. (2018). Industry 4.0: A Korea perspective. *Technological Forecasting and Social Change,* 132, pp. 40–45. doi: 10.1016/j.techfore.2017.11.005

Szozda, N. (2017). Industry 4.0 and its impact on the functioning of supply chains, Scientific journal of logistics 13(4), pp. 401–414.

Tien, J.M. (2012). *Towards the next industrial revolution.* IEEE International Symposium on Logistics and Industrial Informatics. pp. 13–14. doi: 10.1109/LINDI.2012.6319480

Wang, S. Wan. J, Li. D, Zhang. C. (2016). Implementing Smart Factory of Industrie 4 . 0 : *An Outlook*, 2016. doi: 10.1155/2016/3159805

White, L. (2005). Small business: the case of Brazil, The South African Institute of International Affairs 0:1, 117-136, DOI: 10.1080/10220461.2013.781257

Williams, M.S. (2017). Examining the economic impact of Industrial Action activities in South Africa, 2003-2014.

Zuze, H. & Weideman, M. (2013). Keyword stuffing and the big three search engines. *Online Information Review,* 37(2), pp. 268–286. doi: 10.1108/OIR-11-2011-0193

Questionnaire sample

Section A Demographics of organization

1) How long has the business been in operation

Years	
Less than 5 years	1
5-10 years	2
10-15 years	3
More than 20 years	4

2) How many people are employed in your business

No. of employees	
1- 9 (Micro)	1
10-99 (Small)	2
100-199 (Medium)	3

3) Which sector best fits your business

Food and beverage	1
Furniture	2
Plastic and non metallic	3
Steel and metal	4
Chemical and petroleum	5
Clothing and textile	6
Mining	7
ICT and electronics	8
Agriprocessing	9
Other (please specify)	10

4) How do you primarily interact with your customers?

Interaction	
Physically (in store or office	1
Virtually (Online or remotely)	2

Both physically and virtually	3

5) Where do you conduct the majority of your business?

Provinces	
Gauteng	1
Kwazulu-Natal	2
Mpumalanga	3
Rest of South African provinces	4
Africa	5
Other (specify)	6

6) What is your position within the organization

Position	
Director/CEO	1
Senior manager	2
Manager	3
Supervisor/team-leader	4
Specialist	5
Researcher	6
General worker	7
Other (please specify)	8

7) How much industry experience do you have

Years	
Less than 5 year	1
5-10 years	2
10-15 years	3
15-20 years	4
More than 20 years	5

Section B :Challenges that are faced by SMEs

8) To what extent do you experience the following within your company

This affects my company	To no extent	Small extent	Moderate extent	Large extent	Very large extent
Crime	1	2	3	4	5
Corruption	1	2	3	4	5
Labour unrest	1	2	3	4	5
High cost of technology	1	2	3	4	5
Lack of ICT	1	2	3	4	5
Low market accessibility	1	2	3	4	5
Lack of finances	1	2	3	4	5
Inadequate skills levels and training	1	2	3	4	5
Lack of government support	1	2	3	4	5

Service and production capability measure

9) To what extent is the following true for your company

Service and production capability	To no extent	Small extent	Moderate extent	Large extent	Very large extent
Produce according to schedule	1	2	3	4	5
Customize product	1	2	3	4	5
Enough skilled human resources	1	2	3	4	5
Receive positive feedback from customers	1	2	3	4	5
Monitor our production line remotely	1	2	3	4	5
More than 1 product per machine can be manufactured	1	2	3	4	5

Section C: Industry 4.0 knowledge and perception

10) Have you heard of the term industry 4.0 (Kindly refer to cover page)

Yes	1
No	2

11) Where did you first hear about Industry 4.0? Choose one that best describes

Source	
Television	1
Radio	2
Magazine	3
Newspaper	4
Internet	5
Books	6
Formal education	7
Seminars/symposium	8
Other(Specify)	9

Awareness and knowledge of Industry 4.0

12) To what extent are you aware of the below

	Not at all aware	Slightly aware	Somewhat aware	Moderately aware	Very aware
The practicality of industry 4.0	1	2	3	4	5
The relevance of industry 4.0 on production	1	2	3	4	5
The human safety through industry 4.0	1	2	3	4	5
The efficiency of a smart factory	1	2	3	4	5
The cost savings through industry 4.0	1	2	3	4	5
The global move towards industry 4.0	1	2	3	4	5

13) To what extent can the following be benefits in your company

	To no extent	Small extent	Moderate extent	Large extent	Very large extent
Smart Production	1	2	3	4	5
Energy efficiency	1	2	3	4	5
Real time performance	1	2	3	4	5
Product flexibility	1	2	3	4	5

Smart economy(i.e digital economy)	1	2	3	4	5

14) To what extent do you consider the following barriers to implementing industry 4.0

	Not a barrier	Somewhat of a barrier	Moderate barrier	Extreme barrier
Lack of financial resources	1	2	3	4
The high cost makes it impractical	1	2	3	4
Scarcity of skilled workers on industry 4.0	1	2	3	4
Lack of knowledge on the benefits of Industry 4.0	1	2	3	4
Businesses focused on daily operation than technology strategies	1	2	3	4
The economic status of South Africa	1	2	3	4

15) To what extent do you agree with the following statements

	To no extent	Small extent	Moderate extent	Large extent	Very large extent
Industry 4.0 will destroy SMEs	1	2	3	4	5
Industry 4.0 will leave people jobless	1	2	3	4	5
South Africa is not ready for industry 4.0	1	2	3	4	5
Industry 4.0 will hinder entrepreneurship	1	2	3	4	5
Industry 4.0 will enlarge the inequality gap	1	2	3	4	5